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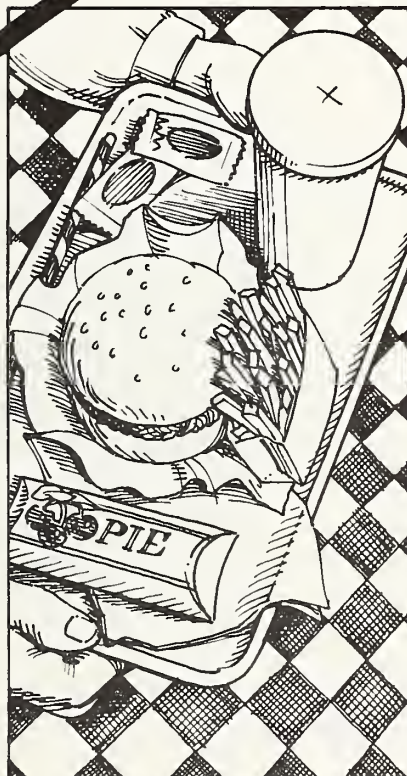


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AGRICULTURAL ECONOMICS RESEARCH

OCTOBER 1980 VOL. 32, NO. 4

FOOD
EXPENDITURES



ENGEL CURVE see page 14

INCOME

AGRICULTURAL ECONOMICS RESEARCH

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IN THIS ISSUE

"Things are seldom what they seem," according to a line in Gilbert and Sullivan's "H.M.S. Pinafore," "Skim milk masquerades as cream." Agricultural economists also have difficulty distinguishing reality from appearances. One might think that hastily drawn, subjective opinions in agricultural economics could be dispelled by referral to data or theory. But experience, and the articles in this issue, show that such efforts may confound rather than ameliorate the problem. Many mistaken beliefs are rooted in inappropriate theories or inaccurate data. Even so, as these articles further demonstrate, which is the skim milk and which the cream can ultimately be judged only by an appeal to data and to theory.

Evans, in the first article, translates the legal language of the Food and Agriculture Act of 1977 into familiar economic jargon so that readers of this journal can see what the law really says. There are a few surprises. The law, apparently aimed at limiting the supply of certain crops as part of the price-support program, raises the marginal revenue to growers and thereby really induces an increase in supply, according to Evans.

Blaylock and Green, in the second article, use a flexible functional form to estimate Engel curves for food. Dick King, in

his 1979 Presidential Address to the American Agricultural Economics Association, pointed out that the choice of functional form used in a demand model may predetermine whether estimated income elasticities rise toward 1.0, fall toward zero, or remain constant as income rises. King warned us not to be any more surprised that the empirically determined elasticities behave as they do for a given functional form than we are surprised when the children find the Easter eggs precisely where they were hidden. Blaylock and Green demonstrate that a flexible functional form permits the data to determine the behavior of the elasticity whereas classical functional forms used to estimate Engel curves impose various predetermined patterns.

Some models which are simple to use and which appear to provide unambiguous results may, in fact, be misleading, not only as to predicted magnitude but also as to predicted directions of change. Single-product models predict that imposing a tariff on wheat imports will decrease the price of wheat in exporting countries and increase the price in the importing country. But Paarlberg and Thompson, in the third article, show that multiple-product models which allow for real income effects and for cross elasticities can, under certain situations, support

a different conclusion. They believe that one needs both an appropriate model and also reliable empirical coefficients to make useful and realistic policy appraisals.

It has long been recognized that food stamps induce increased expenditures for food, but by an amount substantially less than the value of the stamps. Salathe, in the fourth article, adds to this the knowledge that expenditure increases are relatively large for certain commodities, such as cereal products, processed vegetables, and pork. Other purchases of food for home use, such as fish, fruits, and sweeteners, increase only slightly. What may surprise some people is that expenditures for food away from home decrease markedly. Salathe estimates that \$1 of added food stamps resulted in an additional 36 cents of spending for food at home. This was partially offset by a reduction of 14 cents in spending for food away from home, resulting in a net gain in spending for total food of 22 cents per dollar of stamps issued. What appears as a general increase in the demand for food is really the net result of substantial increases for some products, negligible changes for others, and considerable reductions in demand for food away from home.

CLARK EDWARDS

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ACREAGE RESPONSE TO THE TARGET PRICE AND SET-ASIDE PROVISIONS OF THE FOOD AND AGRICULTURE ACT OF 1977

By Sam Evans*

The Food and Agriculture Act of 1977 continued the target price/deficiency payment mechanism for supporting farm income and authorized set-aside and paid-diversion programs to influence production of wheat, feed grains, rice, and cotton during the 1978/79-1981/82 crop years. An important difference between the 1977 act and its predecessor—the Agriculture and Consumer Protection Act of 1973—is that, except for rice, deficiency payments and set-aside and diversion requirements are now based on current plantings rather than on historical acreage allotments. The “current plantings” feature of the 1977 act affects both the distribution of commodity program benefits and also crop acreage response to policy variables such as target prices, set-aside requirements, and diversion programs.¹

In this article, I examine, from a theoretical perspective, farmers’ responses to target prices with and without set-aside controls. I also consider methodological problems from the perspective of an economist who must predict aggregate acreage response to alternative levels of policy variables. Finally, I evaluate the target price adjustment formula in the 1977 act, especially the influence that short-term changes in average yields have on target price determinations.

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¹ For an analysis of the distributional impacts of the 1977 act, see (12). Italicized numbers in parentheses refer to items in References at the end of this article.

The Food and Agriculture Act of 1977 increased the influence of target prices on acreage allocation decisions. Differences between target and market prices were highly correlated with rates of participation in recent grain set-aside programs. But, target prices also encourage set-aside participants to increase acreage of the set-aside crop. The net effect of a set-aside on acreage of a specific crop may, thus, be positive or negative. Deficiencies in the target price formula magnify the potential for target prices to disrupt the allocative function of market prices.

Keywords

*Food and Agriculture
Act of 1977
Target prices
Set-aside
Diversion
Acreage response*

TARGET PRICES

The Agriculture and Consumer Protection Act of 1973 established target prices for wheat, feed grains, and cotton beginning with the 1974 crop year.² Target prices are used to calculate deficiency payments to producers. Deficiency payments are made to eligible wheat and feed grain producers if the national weighted average farm price during the first 5 months of the marketing year is less than the target price. Cotton payments are determined from a comparison of the calendar

² See (5) for detailed provisions of the commodity programs under the 1977 act.

year average farm price with the target price.

The record does not indicate why cotton is treated differently. As deficiency payments (D) are made on new crop production, comparing the target price (P^t) with a calendar year average farm price (P^f)—a mixture of old (P_o^f) and new crop (P_n^f) prices—affects the role the target price plays in cotton producers’ planting decisions.

By definition, $D = P^t - P^f$, where P^f is the weighted average of old crop (January-July) and new crop (August-December) prices, that is, $P^f = W_o P_o^f + W_n P_n^f$. Sales in the first and fourth quarters usually account for the bulk of W_o and W_n , the old and new crop weights, respectively.

When the formula for deficiency payments is rewritten as:

$$D = P^t - W_o P_o^f - W_n P_n^f,$$

we see that the average price for new crop production needed to eliminate deficiency payments ($D = 0$) is:

$$P_n^f = \frac{P^t - W_o P_o^f}{W_n}$$

The value of P_n^f which assures that deficiency payments will not be made may be considered the “effective” target price for the new crop.

If farm prices during the first quarter average below the announced target price ($P_o^f < P^t$), the effective target price is greater than

P^t . For example, if P^t and P^o are 60 and 55 cents a pound, respectively, and W_o and W_n are 0.4 and 0.6, respectively, the effective target price for new crop production is $(60 - 0.4(55))/0.6$ or 63.3 cents a pound. Producers who recognize this have an incentive to increase their cotton acreage. If, of course, $P^o > P^t$, the effective target price is less than P^t , making market prices more important in planting decisions.

Under the 1973 act, acreage allotments were used to determine the production eligible for deficiency payments. The legislation permitted feed grain and wheat producers to collect deficiency payments on "normal" production from their allotment whether or not the crop acreage exceeded the allotment. Cotton producers, however, had to plant at least 90 percent of their allotment to earn the full deficiency payment.³

The 1977 act, by basing deficiency payments on current rather than historical acreage, may make producers (especially of wheat and feed grains) more responsive to target prices than formerly. One can see this greater role of the target price by examining total and marginal revenue functions for program crops under the 1973 and 1977 acts.

Total revenue was $P^f Q + Dq$ under provisions of the 1973 act and is $(P^f + kD)Q$ under provisions of the 1977 act, where P^f is the expected market price, Q is total production, D is the expected deficiency payment, q is normal production from the allotment, and k

is the allocation factor or percentage of production eligible for target price coverage.⁴

Marginal revenue for wheat and feed grain production under provisions of the 1973 act was simply the market price, P^f , as the revenue of Dq was forthcoming regardless of the quantity produced. On the other hand, marginal revenue under provisions of the 1977 act may be higher than the target price: It is $P^f + kD$. Marginal revenue and thus acreage response are influenced by expected deficiency payments.

As producers had to plant cotton to earn any deficiency payment on that crop, marginal revenue under the 1973 act was $P^f + D$ on production from the allotment. But it was only P^f on acreage in excess of the allotment. Thus, a cotton target price greater than the expected market price could have induced producers who would plant less than their allotments on the basis of market price to increase acreage (2, 6). In 1977/78—the last year in which a crop was covered under the 1973 act—cotton acreage in the Southeast was about 50 percent of the region's total allotment, whereas that in the lower

cost regions of the Southwest and West exceeded allotments by 37 and 120 percent, respectively. Compared with the allotment system, the 1977 act, by basing total deficiency payments on current acreage, increased target price coverage for low-cost cotton producers and increased the potential for target prices to influence their planting decisions.

Acreage Response to Target Price: No Acreage Controls

Figure 1 illustrates how, under provisions of the 1977 act, target prices may influence the acreage allocated to a particular crop. The shortrun acreage response function is AA, the target price is P^t , and the expected farm price is P^f . Expected marginal revenue from the combination of P^t and P^f is labeled P^D where $P^D = P^f + kD$, and $k < 1.0$.

If there were no target price or if P^f exceeded the target price, planted acreage would be F when P^f is the expected farm price. However, with target price P^t and allocation factor k , acreage would increase to D as expected marginal revenue increases to P^D . The target price, therefore, generates a new acreage response function for expected farm prices below the target price. In this example, the new curve passes through the point (P^f, D) rather than the original point (P^f, F) . Both curves pass through (P^t, T) as for a farm price of P^t , expected deficiency payments are zero. The resulting "kinked" acreage response curve is labeled BtA (fig. 1). The function BtA shows acreage response to expected farm price when the target price and allocation factor

⁴ The allocation factor is the ratio of national program acreage—estimated acreage needed for domestic, export and stock needs—to actual harvested acreage. The factor must be 0.8 to 1.0 for wheat and feed grains; the minimum cotton national program acreage is 10 million—no minimum allocation factor is specified for cotton. Producers who voluntarily reduce plantings of a crop by a percentage specified by the Secretary of Agriculture are guaranteed target price coverage on their entire acreage of that crop.

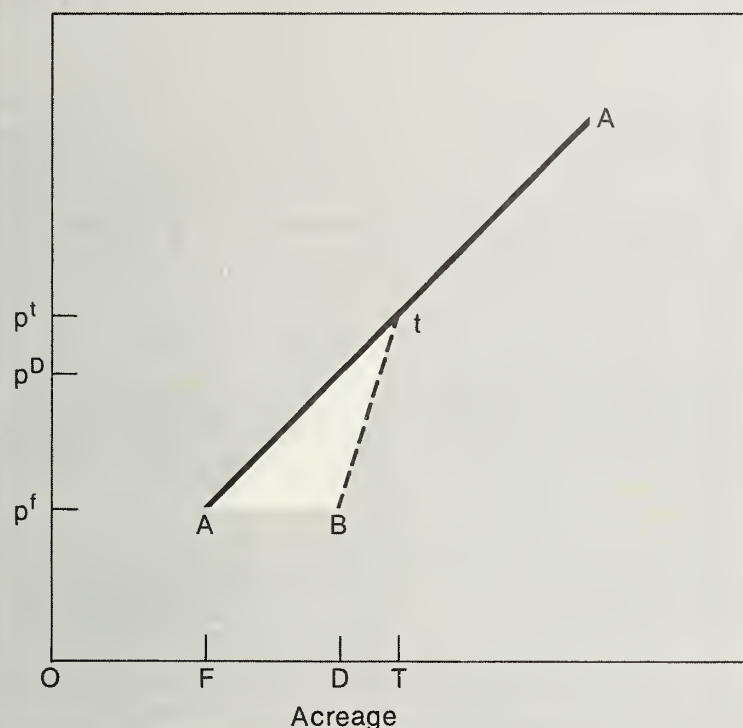
³ See (8).

The 1977 act, by basing deficiency payments on current rather than historical acreage, may make producers (especially of wheat and feed grains) more responsive to target prices than formerly.

Figure 1

Acreage Response to Target Price

Marginal revenue



are given. The horizontal differences between BtA and AA are increases in acreage due to the effects of the target price and allocation factor on marginal revenue. These differences equal $(a)kD$, where a is the acreage change per unit of price change along AA .

As indicated in figure 1, acreage is less responsive to price changes when market prices below the target price are expected. In this example, the acreage change

per unit of price change is $a(1 - k)$.⁵ If the allocation factor were 1.0, marginal revenue would be P^t , and Bt would be a vertical line. For a smaller allocation factor, Bt will shift toward AA , and the target price will have less impact on acreage response.

⁵ One could argue that the target price, by reducing income uncertainty, will dampen the response to market prices even if they exceed the target price. This argument is considered in (3).

FARMER-OWNED RESERVE PROGRAM

Another major provision of the wheat and feed grain program is the farmer-owned reserve. Under this program, farmers contract to store grain for a specific period of time (currently 3 years) or at least until the market price exceeds the loan rate by a specified percentage. This level of market price is termed the "release" price. In return for holding grain off the market until the release price is reached or the contract expires, producers receive an annual storage subsidy (see (5) for further details of the program).

Here I do not consider the release price as the primary supply-inducing price even if it exceeds the larger of the target price or the expected market price. No doubt, the farmer-owned reserve increases price expectations of producers both in and out of the program. However, the release price is not a guarantee. The contract may expire without the release price being reached. Instead, the release price sets an approximate upper bound on the final selling price (7). Moreover, a specified release price larger than the target price does not rule out deficiency payments which influence farmers' acreage decisions under provisions of the 1977 act.

Farmers must ultimately form subjective expectations not only of the selling price under the reserve program but also of the time path of price movements. The time dimension suggests that the expected selling price must be discounted. That is, the present value of the expected selling price (including the net storage subsidy) compared with alternative price

expectations, such as the target price or current market price, is what may be relevant to producers' acreage allocation decisions.

SET-ASIDE PROGRAMS

The 1977 act maintains the Secretary of Agriculture's authority to implement a set-aside program when excessive supplies of cotton, wheat, rice, or feed grains are projected. Unlike previous legislation which expressed the set-aside requirement as a percentage of an allotment based on historical acreage, the 1977 act expressed the set-aside requirements as a percentage of current plantings. For example, a corn set-aside of 10 percent requires participating producers to set aside an acre of cropland for every 10 acres of corn planted. This does not necessarily mean that corn acreage will be less. Rather, it means that, for each acre set aside, a corresponding reduction must be made in the acreage of crops "normally" planted on the farm.⁶

The 1977 act gave the Secretary authority to institute cross-compliance requirements when a set-aside for one or more crops is in effect. For example, if there is a set-aside for corn, a producer growing corn must comply with

this requirement to be eligible for benefits from any farm program. Compared with no provision for cross-compliance, the 1977 act may increase producer participation in set-aside programs, especially when market prices are weak.

Factors Affecting Participation in Set-Aside Programs

The decision to participate in a set-aside program is complex. It requires farmers to weigh potential benefits from the farm programs against the net revenue they can expect to lose by taking land out of production. Many benefits gained through participation cannot be quantified. For example, what is the value of the economic security provided by the complete farm program for a commodity? How does one measure the value of being eligible for disaster payments and for the loan and farmer-owned reserve programs?⁷ The cross-compliance requirement also complicates the process of estimating benefits of participation as it requires the farmer to estimate the value of benefits from all program commodities produced on the farm.

The most measurable incentive for participation in a set-aside program is probably the difference between the target price and the

expected market price of a commodity. As will be shown later, changes in the expected deficiency payment (combined in some cases with a diversion payment) agreed closely with changes in the rates of participation in the 1978 and 1979 wheat and feed grain programs.

If there were a set-aside requirement for corn, for example, expected returns per acre of corn harvested by participants would be:

$$(P_c^f - C_c + k_c D_c) Y_c^p,$$

where P_c^f , C_c , k_c , D_c , and Y_c^p are, respectively, expected market price, per bushel production costs, the allocation factor, the expected deficiency payment, and the "payment" yield for corn.⁸

⁸ The "payment" yield—the yield used by the U.S. Department of Agriculture to calculate total deficiency payments—is loosely based on yields for the previous 3 years. If, for some reason, expected yields were less than the payment yield, the target price would figure more prominently in planting decisions. Pawson (6) indicated, for example, that cotton payment yields in 1972 in some regions were 55 percent higher than normal yields. From data in (10), I found that cotton payment yields for the 1978 paid-diversion program averaged 663 pounds per planted acre. For the three seasons prior to 1978/79, cotton yields per planted acre averaged about 462 pounds, a near-normal yield. Moreover, nearly 40 percent of the diverted acreage was in Texas where yields are usually well below the national average; only 5 percent was in California and Arizona where yields are well above the national average.

⁶ The 1977 act provided for establishing a normal crop acreage (NCA) based primarily on 1977 plantings for each farm. When a set-aside is in effect, a participant's planted acreage of the normal crops plus the acreage designated as set-aside cannot exceed the NCA. This change was made to reduce "slippage," the tendency for the acreage put into conserving uses to exceed the reduction in planted acreage of the controlled crops (1).

⁷ Problems of measuring the present value of the release price specified in the farmer-owned reserve were discussed earlier. As the reserve program raises price expectations for all producers, the release price itself may not be the important factor affecting participation decisions. The level of storage subsidy paid to participants may well be the key variable.

By participating in the set-aside program, a producer increases net returns from an acre of corn by $k_c D_c Y_c^p$ and reduces total variable costs by the proportion of acreage idled. There is, however, an opportunity cost associated with participation as income is foregone from the acreage set aside. This loss may be offset partially by returns from permitted uses of the conserving acreage. The net opportunity cost per acre planted is, therefore, $S_c (RF - RP)$, where S_c is the set-aside percentage, RF is the foregone net revenue per set-aside acre, and RP is per acre net revenue from the best permitted use of the set-aside acre.

A profit-maximizing producer will participate in a set-aside program if

$$k_c D_c > S_c \frac{(RF - RP)}{Y_c^p}, \quad (1)$$

where the term on the left is the gain per bushel produced, while that on the right is foregone net revenue per bushel. The difference, $k_c D_c - S_c (RF - RP)/Y_c^p$, is a measure of the incentive to participate in a set-aside program.

The foregone net revenue (RF) may represent a reduction in corn acreage, in which case $RF = (P_c^f - C_c) Y_c^w$, where Y_c^w is the average yield per acre withheld from production. The foregone yield (Y_c^w) is likely to be less than the average yield on planted acres as farmers tend to idle their least productive

land.⁹ The foregone net revenue may also result from a reduction in acreage of other crops in the NCA. A farmer growing corn and soybeans could meet corn set-aside requirements by reducing either soybean or corn acreage, or both.

Combined Set-Aside and Diversion Programs

Under the 1978/79 and 1979/80 feed grain programs, producers who complied with set-aside requirements could also voluntarily divert to conserving uses additional acreage equal to 10 percent of current plantings. Participants in this voluntary program received a diversion payment on normal production from their planted acreage of the particular crop.

Equation (1) may be expanded to include the option of diverting acreage for payment. A profit-maximizing producer will participate in both the set-aside and diversion program if,

$$k_c D_c + R_c > (S_c + Z_c) \frac{(RF - RP)}{Y_c^p}, \quad (2)$$

where R_c and Z_c are, respectively, the per bushel diversion payment and the diversion percentage applied to current plantings. If $R_c > Z_c (RF - RP)/Y_c^p$, a diversion program will strengthen the incentive to set aside.

Sample Calculations of Participation Incentives

I calculated a measure of the incentives to participate in the recent wheat and feed grain programs with the simplifying assumptions that $k = 1.0$, $RF = (P^f - C)$, and $RP = 0$. The table presents the results along with "actual" participation rates.

Although the calculations only crudely approximate aggregate participation incentives, they provide some valuable insights. Moreover, changes in the estimated incentives agree closely with changes in actual participation rates. The reason for greater participation in the wheat programs was a wider difference between the target price and expected (previous season) farm price of wheat. For all three crops, participation in the set-aside programs declined in 1979/80 as farm prices increased relative to target prices, thereby

⁹The opportunity to set aside less productive land, a factor in the set-aside decision, varies widely across the United States and may be related to farm size. Data show that, of the farms participating in the 1978/79 wheat and feed grain programs, those largest in terms of NCA had the smallest foregone net income per set-aside acre, and the rate of participation in the set-aside programs was also positively related to farm size (12, pp. 28, 38). To the extent that land of below-average productivity is set aside, the ability of the program to control production is reduced. And, as the distribution of commodity program benefits among farm-size groupings depends on both current plantings and participation rates, the presumed opportunity for larger farms to set aside relatively unproductive land increases the tendency for program benefits to be skewed toward larger farms.

Calculation of set-aside and diversion incentives

Year	Crop	Requirement per planted acre		Price			Expected deficiency payment ⁴	Diversion payment	Average variable cost ⁵	Program participation incentives		Acreage ⁸			Estimated participation				
		Set-aside S	Diversion Z	Farm ¹ p _f	Loan ² p _l	Target ³ p _t				D	R	C	Set-aside ⁶	Diversion ⁷	Plant- ed	Set- aside	Divert- ed	Set- aside ⁹	Diversion ¹⁰
		Acres		Dollars per bushel										Million acres				Percent	
1978/79	Wheat	0.2	0	2.33	2.35	3.00	0.65	—	1.23	0.43	—	66.3	9.6	—	72	—			
1979/80	Wheat	.2	0	2.98	2.35	3.40	.42	—	1.29	.08	—	71.6	8.2	—	57	—			
1978/79	Corn	.1	.1	2.02	2.00	2.10	.08	0.20	1.11	-.01	0.11	80.1	3.2	2.9	40	90			
1979/80	Corn	.1	.1	2.25	2.00	2.20	0	.10	1.10	-.11	-.02	80.0	1.7	1.1	21	65			
1978/79	Sorghum	.1	.1	1.82	1.90	2.28	.38	.12	1.13	.31	.05	16.5	1.1	.3	67	27			
1979/80	Sorghum	.1	.1	2.02	1.90	2.34	.32	.10	1.14	.23	.01	15.4	.8	.3	52	38			

¹ Average for previous season.² In January 1980, loan rates for 1979/80 were increased to \$2.50 for wheat, \$2.10 for corn, and \$2.00 for sorghum.³ In May 1978 (after 1978/79 planting season), the wheat target price was raised to \$3.40.⁴ Difference between p_t and larger of p_f and p_l.⁵ Calculated from (13). Average yields of previous three seasons were used.⁶ Incentive is: D - S(p_f - C), assuming allocation factor of 1.0.⁷ Given set-aside participation, incentive is: R - Z(p_f - C).⁸ See (15, 16).⁹ Percentage is: $\frac{\text{acres set aside}}{\text{acres planted}} (100)$.¹⁰ Percentage is: $\frac{\text{acres diverted}}{\text{acres set aside}} (100)$.

— = Not applicable.

reducing the participation incentive. Furthermore, the feed grain diversion payments were lower in 1979/80.

The corn diversion payment provided most of the incentive for producers to comply with its set-aside requirements (see table). In 1978/79, 90 percent of the eligible acreage was enrolled in the diversion program. That is, nearly everyone who set aside acreage also found it profitable to divert additional acreage for the 20-cents-per-bushel payment. This is not surprising as the diversion payment was double the maximum possible deficiency payment.

In contrast with corn, wide differences between the target price and the farm prices or loan rates for grain sorghum in 1978/79 and 1979/80 resulted in relatively high rates of participation in grain sorghum set-aside programs. In fact, the data suggest that a set-aside program alone, particularly in 1978/79, may have achieved results in grain sorghum markets not significantly different from those achieved by the set-aside/diversion program.

Acreage Response to Set-Aside Incentives

When a set-aside is in effect under provisions of the 1977 act, a target price greater than the expected market price influences acreage response in two ways. First, the target price provides a measurable incentive to reduce acreage by participating in the set-aside program; second, it provides an incentive to increase production of the controlled crop as deficiency payments increase marginal revenue for participants. From the first

effect, we can visualize a leftward (negative) shift of the acreage response curve for set-aside participants, reflecting the increased opportunity costs of producing the set-aside crop. From the second effect, we can visualize the response to the target price as an upward movement along the acreage response curve for participants, reflecting a positive influence on acreage. Whether acreage of the controlled crop increases or decreases under a set-aside program depends, therefore, on the relative strengths of these opposing effects.

A simple model was formulated to illustrate the acreage response to set-aside incentives. The model is for a farm which grows two crops (X and Y) and on which there is a set-aside requirement for X. Profit (π) functions are:

$$\begin{aligned}\pi_0 = & P_x f_x(Ax) \\ & + P_y f_y(At - Ax) \quad (3) \\ & - (C^k + C^v) At\end{aligned}$$

for the nonparticipant and

$$\begin{aligned}\pi_1 = & (P_x + D_x) f_x(Ax) \\ & + P_y f_y(At - (1 + S_x)Ax) \quad (4) \\ & - C^k At \\ & - C^v (At - S_x Ax)\end{aligned}$$

for the set-aside participant, where P_x and P_y are expected market prices of X and Y, respectively; Ax and $At - Ax$ are planted acreages of X and Y, and At is total acreage available; C^k and C^v are fixed and variable production costs

per acre, assumed to be equal for producing either X or Y; D_x is the expected deficiency payment per bushel of X produced; S_x is the set-aside rate; and f_x and f_y are the respective production functions.

Furthermore, let $P_x = \$5$ per bushel, $P_y = \$6$ per bushel, $At = 5$ (units of land), $C^v = C^k = \$100$ per acre, and production functions of X and Y be: $Q_x = 50 Ax - Ax^2$ and $Q_y = 40 Ay - 2 Ay^2$. Alternatively, $Q_y = 40 (At - Ax) - 2 (At - Ax)^2$.

Figure 2 shows profit functions for the situations labeled I-IV. They differ as follows: Situation I assumes no farm program and also represents the profit curve for non-participants given the above assumptions; situations II - IV assume a 10-percent set-aside requirement for X ($S_x = 0.1$), with successively higher target prices of \$5.50, \$6, and \$6.50 per bushel of X ($D_x = \$0.50, \$1, \text{ and } \$1.50$, respectively, given $P_x = \$5$).

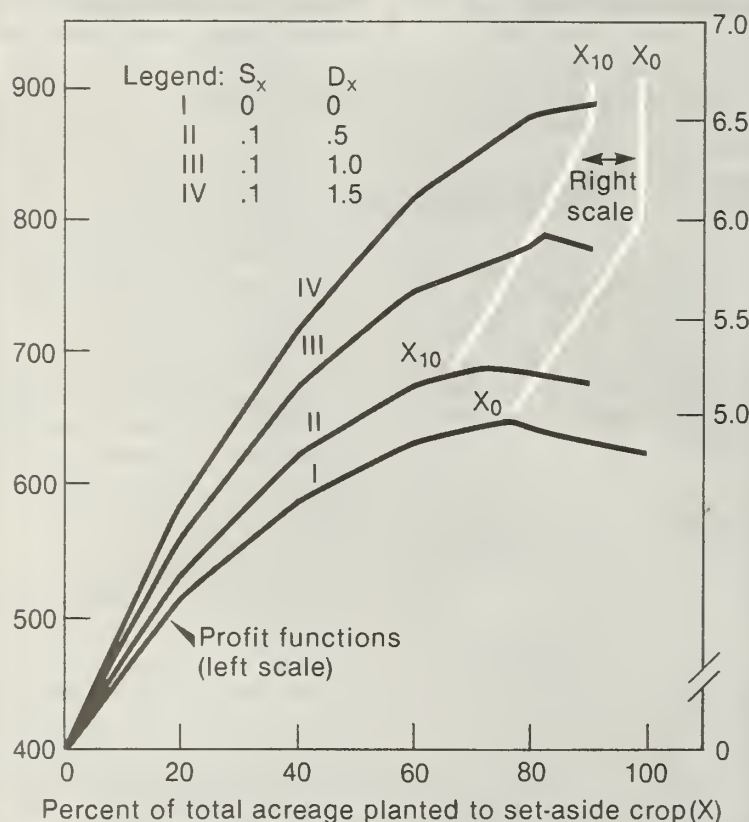
Assuming no set-aside restrictions, I solved the model to derive the acreage response of X to marginal revenue (right scale, fig. 2). The resulting function is labeled X_oX_o . When a set-aside is in effect, two questions are relevant: Will the farmer participate in the program, and how will acreage be allocated between crops X and Y? Those questions may be answered after an examination of the profit functions. As the profit functions for situations II-IV lie above that for the nonparticipant, participating in any of the alternative set-aside programs is the more profitable action. The optimum planted acreages of X under the set-aside programs correspond to the maximum values of the profit functions. One can derive

Figure 2

Derivation of Acreage Response to Target Prices Under a Set-Aside Program

Returns above variable costs, dollars

Target price or marginal revenue, dollars/unit



the acreage response curve of X to target prices given a 10-percent set-aside rate by plotting these optimum acreages (percentages of total acreage) against the righthand scale in figure 2. The resulting curve is labeled X_{10} .

The curve X_{10} lies to the

left of X_0 due to the higher opportunity costs of producing X. However, as the target price of X increases, acreage of X increases and acreage of Y decreases. For target prices greater than about \$5.75/bu., acreage of X exceeds the acreage that would be planted

under the no set-aside alternative. Eventually, for a target price of about \$6.50 per bushel, the acreage of X reaches its maximum under the set-aside rules ($Ax^{\max} = At/1.1$) and the acreage of Y = 0.¹⁰

Aggregate Response

Analyzing aggregate acreage response to set-aside incentives is infinitely more complex than the simple model suggests. Such analysis requires identifying the acreage response curve(s) of set-aside participants as well as estimating the response by nonparticipants. As most crops are grown over a wide geographical area and under a variety of economic and technical conditions, participation rates and participant responses to target prices will vary greatly from region to region. Program benefits depending on cross-compliance requirements may also differ significantly

¹⁰ On May 15, 1978, President Carter signed the Emergency Agricultural Act of 1978. This legislation gives the Secretary of Agriculture discretionary authority to raise target prices for wheat, feed grains, and cotton whenever a set-aside is in effect for one or more of these crops (9, p. 11). As this article indicates, participation in a set-aside program would be greater for a higher target price. However, the higher target price may cause farmers who would set aside for a smaller incentive to increase acreage of the set-aside crop. It should be recognized that a potential result of increasing the target price to compensate set-aside participants is that acreage of the set-aside crop could be little changed (or even greater), but deficiency payments could be higher.

from region to region, thereby causing differing participation rates. For example, cotton program benefits may be an important factor in a Texas producer's decision to participate in a feed grain set-aside, but those benefits are not a factor in an Iowa producer's decision. Such considerations suggest that predicting the total impact of set-aside programs on crop acreages and production requires a highly disaggregated analysis.

THE TARGET PRICE FORMULA

It should now be clear that target prices under the 1977 act have a greater potential to interfere with the allocative function of market prices than under the 1973 act. This potential is magnified by the formula for target price adjustments. The formula is:

$$P_{n+1}^t = P_n^t + \left(\frac{C_n}{Y_n} - \frac{C_{n-2}}{Y_{n-2}} \right) (0.5) \quad (5)$$

where P^t is the target price; n is the current crop year; C is the sum of variable, machinery, and overhead costs per planted acre for the specific crop; and Y is yield per planted acre (7).

As per unit costs in only 2 years influence the adjustments, yield variations are potentially a major source of target price adjustments. For example, high yields in " n " relative to " $n - 2$ " could cause a downward adjustment in the target price even though per acre costs may be increasing rapidly. The formula may result in target price adjustments that are out of phase

with changes in average costs based on normal or expected yields, and, consequently, the substitution of one crop for another. Inflated corn or cotton target prices resulting from a particular pattern of yields could cause these crops to substitute for soybeans.

A second characteristic of the adjustment formula that may cause target prices to misrepresent current costs relates to the cumulative nature of the adjustments. From equation (5), it can be shown that the target price in any one year during 1979-81 is linked to 1978 (base year) target price as follows:

$$P_{78+n}^t = P_{78}^t + \frac{C_{78+n-1}^u + C_{78+n-2}^u - C_{77}^u - C_{76}^u}{2} \quad (6)$$

where $n = 1, 2$, or 3 and $C^u = C/Y$, or average costs.

Equation (6) indicates that abnormally high yields in either 1976 and 1977, or both, would have tended to bias the target price upward; abnormally low yields would give a downward bias. Distortions in relative target prices could persist throughout the period if yields of one crop had been high in 1976 or 1977 and those for another crop had been low.

The problems with the target price formula specified by the 1977 act are well recognized, particularly those caused by random yield variations. These problems have contributed to the passage of legislation increasing the degree of discretionary authority given to the Secretary of Agriculture with respect to establishing target

price levels. As noted earlier, in 1978 the Secretary was authorized to raise target prices above formula levels for set-aside participants, and on March 18, 1980, President Carter signed the Agricultural Adjustment Act of 1980 (H.R. 3398). This legislation permits the Secretary to raise feed grain and wheat target prices for the 1980 and 1981 crops above formula levels. To qualify for the higher targets, producers must plant within their normal crop acreage. Speaking on behalf of H.R. 3398, Howard Hjort commented:

If we could be assured that yields per planted acre would again increase in 1980 we would not need to be concerned over the formula target prices. And while no one knows what yields will be in 1980, the odds clearly are in favor of national average yields below the exceptional ones observed in 1979. If this happens, it is clear that the 1980 target prices will be well below the level that would permit most producers to cover the costs they cannot postpone (4).

It is clear that the current formula must be revised to give more weight to changes in per acre production costs and less to random yield variations. If a satisfactory formula is not developed, target price adjustments are likely to become increasingly discretionary and, thus, increasingly subject to political pressures.

CONCLUSIONS

The Food and Agriculture Act of 1977 increased the influence of

target prices on resource allocation decisions both by requiring wheat and feed grain producers to plant those crops to qualify for deficiency payments and also by basing the amount of payments on current, rather than historical, acreages of program crops. These provisions make expected marginal revenue from program crops depend on deficiency payments.

When there are no set-aside restrictions, the target price causes producers to be less responsive to changes in market prices if market prices are below the target price. When set-aside restrictions are in effect, target prices play a dual role. The difference between the target price and the expected market price gives producers a measurable incentive to participate in the set-aside program which has a negative influence on acreage of the controlled crop. For example, analysis of the 1978 and 1979 wheat and feed grain set-aside programs showed a close agreement between participation rates and expected deficiency payments. Target prices increase the marginal revenue of the controlled crop for set-aside participants, which has a positive influence on acreage. Thus, it is virtually impossible to generalize about the net effects of a set-aside program on acreage and on production of a specific crop. This suggests that establishing values for policy variables such as the set-aside rate and the target price is a delicate matter, requiring a thorough analysis of the impacts on crop acreage.

The greater role of the target price under provisions of the 1977 act has focused attention on the target price adjustment formula.

Deficiencies in the formula, particularly those related to short-term yield changes, may cause target prices to be out of phase with changes in current production costs, thereby magnifying the potential for target prices to influence resource allocation decisions.

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ANALYSIS OF FLEXIBLE ENGEL FUNCTIONS

By James Blaylock and Richard Green*

INTRODUCTION

When quantifying the income-expenditure relationship at the disaggregated commodity level, economic researchers have generally used cross-section data with little theoretical guidance for choosing the appropriate functional form. A variety of functional relationships have been suggested to represent Engel curves, but no single form has found general acceptance (4, 6, 7).¹ The most widely used "classical" forms include the linear, double-logarithmic, semi-logarithmic, inverse, and logarithmic-inverse functions; however, few statistical techniques exist for selecting the appropriate function. This is an important issue as previous research indicates that the choice of functional form can influence the estimated income (expenditure) elasticities substantially at both the sample means and other points (6). Although selecting the appropriate functional relationship is necessary to characterize elasticities properly and to improve statistical fit, the choice should be made on a systematic and statistically sound basis.

The development of the Box-Cox transformation (1) makes it possible to approach the problem of functional forms with a more

Quantifying the relationship between expenditure for a commodity and household income (Engel analysis) has focused on the use of classical functional forms with few rigorous procedures available for selecting the most appropriate function. We employ flexible functional forms (Box-Cox curves) to distinguish statistically among classical curves. These flexible forms are a natural extension of the class of mathematical models useful for Engel analysis. We compare the Box-Cox curves and the traditional functions using the criteria of flexibility, predictive performance, and elasticity behavior. The flexible forms are preferred for all but one of the commodities considered.

Keywords

Box-Cox curves
Engel analysis
Flexible functional forms
Heteroskedasticity

formal method as the "classical" functions just mentioned are special cases of the Box-Cox model. This transformation allows more flexibility in determining the degree and type of nonlinearity than does prior specification.

In this article, we investigate Box-Cox functions as a decision-making device for discriminating among classical functional forms and for establishing their validity as a natural extension of the mathematical models which characterize Engel relationships.

We estimate Engel curves for multiparameter Box-Cox functions and the "classical" forms for five food commodities. We analyze and evaluate these alternative models

according to their flexibility, predictive performance, and elasticity behavior. In addition, we examine the robustness of all parameter estimates to heteroskedasticity of the error variance and employ a correction procedure when necessary.

BASIC MODELS

The studies by Prais and Houthakker (6) and Salathe (7) are two among several that attempt to select the most appropriate functional form for Engel curves based on intuitive considerations and non-rigorous statistical testing. Generally, the following functional forms have been hypothesized for Engel curves based on *a priori* considerations:²

$$y_i = a + bx_i$$

(linear) Model 1a

$$\ln(y_i) = a + b \ln(x_i)$$

(double-log) Model 1b

$$y_i = a + b \ln(x_i)$$

(semi-log) Model 1c

$$y_i = a - b/x_i$$

(inverse) Model 1d

$$\ln(y_i) = a - b/x_i$$

(log-inverse) Model 1e

where y_i denotes expenditure on a given commodity, x_i represents

² *A priori* considerations include some or all of the following factors: the adding-up criteria, saturation and minimum purchase levels, elasticity behavior over various income ranges, and simplicity of estimation.

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¹ Italicized numbers in parentheses refer to items in References at the end of this article.

income, $i = 1, \dots, N$, and N denotes the number of observations.

The Box-Cox function provides a convenient framework for distinguishing among models (1a-1e) and among numerous other specifications. Given any positive random variable w , we can represent the Box-Cox transformation as:

$$w^* = (w^\lambda - 1)/\lambda, \lambda \neq 0$$

$$= \ln(w), \lambda \rightarrow 0 \text{ (see (1))}$$

where λ is an unknown parameter to be estimated. Applying this transformation to the equation $y_i = a + bx_i$ yields:

$$y_i^* = a + bx_i^{**} \text{ Model (2)}$$

where $y_i^* = (y_i^r - 1)/r$ and $x_i^{**} = (x_i^u - 1)/u$.

Model (2) is a double transformation parameter Box-Cox representation of an Engel curve that encompasses models (1a-1e) as special cases. Specifically:

If $r = 1$ and $u = 1$,
then model (2) $\rightarrow$ model 1a.

If $r \rightarrow 0$ and $u \rightarrow 0$,
then model (2) $\rightarrow$ model 1b.

If $r = 1$ and $u \rightarrow 0$,
then model (2) $\rightarrow$ model 1c.

If $r = 1$ and $u = -1$,
then model (2) $\rightarrow$ model 1d.

If $r \rightarrow 0$ and $u = -1$,
then model (2) $\rightarrow$ model 1e.

Other values of the transformation parameters are, of course, possible and likely. As previously

stated, models (1a-1e) are frequently employed as functional forms to describe the income-expenditure relationship for food commodities. As models (1a-1e) are special cases of model (2), standard statistical tests can be used to distinguish among these models.

A special case of model (2) arises when r equals u . This single parameter transformation takes the form:

$$y_i^* = a + bx_i^* \text{ Model (3)}$$

where $y_i^* = (y_i^p - 1)/p$ and $x_i^* = (x_i^p - 1)/p$. Model (3) encompasses the linear and double-log functions if $p = 1$ and $p \rightarrow 0$, respectively.

The elasticity of y_i with respect to x_i can be shown to be:

$$\xi_{yx} = b(x_i^u/y_i^r)^3 \text{ Equation (4)}$$

The sign of (4) depends on the sign of b as y and x are constrained to be nonnegative. The magnitude of (4) depends on the relative values of y and x and on the values of the transformation parameters. In the double-log case, $r \rightarrow 0$ and $u \rightarrow 0$; hence, $\xi_{yx} = b$. For the log-inverse case, $r \rightarrow 0$ and $u = -1$, which implies $\xi_{yx} = b/x_i$. All the elasticities corresponding to the five classical functions (1a-1e) are limit-

³ Equation (4) refers to the calculation of expenditure elasticities. Expenditure elasticities are defined as the percentage change in expenditure due to a 1-percent increase in income. Income elasticities, on the other hand, are defined as the percentage change in quantity demanded due to a 1-percent increase in income. Due to data limitations, only reported income is available; hence, y_i includes savings.

ing cases of equation (4), and, furthermore, these special cases have elasticities which are either constant or tend toward zero or 1 as income increases.

Logarithmically transforming a functional relationship alters the distribution of the disturbances. Hence, comparing regressions with and without transformations applied to the dependent variable is difficult. The maximum likelihood procedures used to estimate the Box-Cox functions allow one to make a statistical inference concerning alternative hypotheses with standard likelihood ratio methods and t-tests. Also, note that transforming the dependent variable of a model logarithmically will correct for heteroskedasticity if the error variance is proportional to the square of the expected value of the dependent variable.

Applying the Box-Cox transformation to the dependent variable can result in inconsistent estimates of all parameters in the model if the error term is heteroskedastic (10). The estimation process will bias the transformation parameter (r) in the direction of stabilizing the error variance. Zarembka outlines a procedure which will simultaneously test for heteroskedasticity and provide approximately consistent parameter estimates (10, pp. 93-95). As nonspherical errors are frequently encountered in cross-sectional data, one should approach homoskedasticity of the error variance.

The data base used for estimating the above models was the U.S. Department of Agriculture's Household Food Consumption Survey of 1965. The large number of observa-

tions in the survey made it convenient to restrict the sample to the urban section of the Northeast region, which contains approximately 1,000 observations. We chose this subsample for purposes of illustration.

We estimated Engel curves representing models (1, 2, and 3) for beef, pork, poultry, fish, and eggs, using commodity expenditures and household income, both divided by household size, as variables. An extension of this analysis would include both income and household size as separate independent variables. Research has indicated that when expenditures and income are on a per capita basis the appropriate functional form may differ substantially from the appropriate form when household size and income are entered separately (7).

We compared the predictive ability of the alternative models by employing a uniform random process to select 500 observations from which we estimated the models. The estimated parameters were then used to simulate the remaining sample expenditures. After performing suitable manipulations to convert all values to the same numerical base, we calculated and compared the Thiel inequality coefficients. We based the analyses of residuals, flexibility, and elasticities on consistently estimated parameters, using all observations contained in the urban section of the Northeast region.

ESTIMATION PROCEDURES

Estimating the Box-Cox model requires the use of nonlinear maxi-

mum likelihood techniques.⁴ Model (2), when modified to include a random error term, ϵ_i , which is assumed to be normally distributed with zero mean and constant variance σ^2 , for a given r and u , is:

$$y_i^* = a + bx_i^{**} + \epsilon_i, \quad i = 1, \dots, N. \quad \text{Equation (5)}$$

The likelihood function corresponding to (5) is given by:

$$L = (2\pi\sigma^2)^{-N/2} \exp\left[\frac{-1}{2\sigma^2} \sum_i (y_i^* - a - bx_i^{**})^2\right] |J| \quad \text{Equation (6)}$$

where $|J|$ denotes the Jacobian of the inverse transformation from y_i^* to the observed y_i 's:

$$|J| = |\det(\partial y_i^* / \partial y_i)| = \prod_i (y_i)^{r-1}. \quad \text{Equation (7)}$$

It follows that estimating equation (5) can be accomplished by maximizing the natural logarithm of the likelihood function (LL):

$$\begin{aligned} LL = & - (N/2) \ln \{\sigma^2\} \\ & - (1/2\sigma^2) \sum_i [y_i^* - a - bx_i^{**}]^2 \\ & + (r-1) \sum_i \ln \{y_i\} + c \end{aligned} \quad \text{Equation (8)}$$

where c is a constant. Equation (8) can be estimated with a nonlinear

optimizing algorithm, but some simplifications are possible.

For any given values of r and u , one finds the maximum likelihood estimators of σ^2 , a , and b by equating the partial derivatives of LL with respect to a , b , and σ^2 to zero, which yields the following equations:

$$\begin{aligned} \hat{a} &= [\sum_i y_i^* - \hat{b} \sum_i x_i^{**}] / N \\ \hat{b} &= [\sum_i y_i^* x_i^{**} - (\sum_i y_i^* \sum_i x_i^{**}) / N] / \\ & \quad [\sum_i (x_i^{**})^2 - (\sum_i x_i^{**})^2 / N] \\ \hat{\sigma}^2 &= \sum_i [y_i^* - a - \hat{b} x_i^{**}]^2 / N \end{aligned}$$

where $\hat{a}$, $\hat{b}$, and $\hat{\sigma}^2$ represent estimates. Therefore, given initial values of r and u , the remaining parameters a , b , and σ^2 can be estimated by conditional regression, leaving only the transformation parameters to be estimated by a nonlinear algorithm.

The actual procedure used was to scan the parameter space for reasonable starting values of r and u over the range $(-7, 7)$. This two-dimensional search produced excellent initial values of the parameters and virtually guaranteed convergence to a global maximum. We obtained consistent estimates of the asymptotic standard errors for the parameters from the negative of the inverse matrix containing the second partial derivatives of the appropriate likelihood function:

$$\Omega = - \{ \partial^2 L(\theta) / \partial \theta \partial \theta' \}^{-1} \quad \text{Equation (9)}$$

⁴ The Fletcher-Powell algorithm (3) was used in this analysis.

where θ is a vector of parameter values and the matrix is evaluated at $\theta = \hat{\theta}$. Estimation of model (3) utilized the procedural form outlined for model (2).

Zarembka indicates that a consistent estimate of the transformation parameter on the dependent variable is a sufficient condition for consistent estimation of the remaining parameters (10, p. 94). One can obtain consistent estimates of r and u (the same procedures apply to the single transformation parameter case) under heteroskedasticity of ϵ by finding those values of r and u such that the following equation holds:

$$\partial LL / \partial r = (1 - r - h) (N)$$

$$[\text{var}(\ln\{y\})] / [(1/2) +$$

$$(1 - r - h)^2$$

$$[\text{var}(\ln\{y\})]]$$

Equation (10)

where $\partial LL / \partial r$ is the first derivative of the log-likelihood function (LL) with respect to r , and h is chosen to reflect the heteroskedasticity.

For this analysis, a value of h equal to 1 is assumed, which implies that the variance of y_i increases with the square of its expected value. If the values of r and u which maximize the likelihood function do not differ significantly from the values of r and u obtained from equation (10), then either heteroskedasticity is unimportant and r and u reflect nonlinearity or the estimated value of r , while now reflecting non-

linearity, is also the value of r which stabilizes the error variance. However, if the values are significantly different, heteroskedasticity is influencing the estimate of r obtained from maximizing the likelihood function and consistent estimates of r and u will be provided by equation (10). Model (2) together with the heteroskedastic aspects of equation (10) will be referred to as model (4a), while model (3) with the heteroskedastic relation in equation (10) will be referred to as model (4b). That is, model (4a) is the double transformation parameter function with heteroskedasticity, while model (4b) is the single parameter function with a heteroskedastic disturbance term.

EMPIRICAL RESULTS

Table 1 presents the maximum likelihood estimates and the corresponding standard errors of the transformation parameters for models (2), (3), (4a), and (4b).

The transformation parameter estimates for beef, pork, and fish appear robust as to heteroskedasticity because little difference exists either between the parameter estimates of models (2) and (4a) for the double-parameter situation or between models (3) and (4b) for the single-parameter situation. However, this is not true for poultry and eggs. Heteroskedasticity has apparently biased the estimation of the transformation parameter on the dependent variable; hence, models (4a) and (4b) provide a

Table 1—Transformation parameter estimates for models (2), (3), and (4)

Commodity	Model (2)		Model (4a) ¹		Model (3)	Model (4b) ¹
	r^2	u^2	r	u	ρ^2	ρ
Beef	0.16 3(.01)	-.08 (.01)	0.18 (.02)	-.08 (.02)	0.16 (.03)	0.18 (.03)
Pork	.16 (.02)	.06 (.01)	.14 (.02)	.07 (.01)	.17 (.05)	.13 (.04)
Poultry	.02 (.02)	.23 (.27)	.22 (.05)	.16 (.03)	.02 (.001)	.21 (.02)
Fish	.11 (.01)	.40 (.02)	.13 (.02)	.42 (.08)	.11 (.03)	.10 (.02)
Eggs	.01 (.07)	-.05 (.07)	.16 (.27)	-.13 (.25)	.01 (.07)	.17 (.12)

¹Models (4a) and (4b) refer to parameter estimates under heteroskedasticity of the error term. The variance of the error term is assumed to increase with square of the expected value of the dependent variable.

²The parameters r , u , and ρ refer to the transformation parameters associated with the dependent variable, independent variable, and both the dependent and independent variables, respectively.

³Values in parentheses are standard errors.

consistent estimate of the parameters for the double- and single-parameter cases, respectively. Here we will regard the parameter estimates derived from these models as the maximum likelihood estimates of the Engel curves considered. To provide a uniform basis for using significance tests, we corrected the classical functions for heteroskedasticity. That is, we estimated the linear, semi-logarithmic, and inverse functions under the assumption that the error variance is proportional to the square of the expected value of the dependent variable. Recall that the double-logarithmic and logarithmic-inverse functions satisfy this condition automatically for the error variance.

We used significance tests as one way to select which of the traditional functions provides a reasonable fit to the data. We used the likelihood ratio method to test the null hypotheses that no significant difference exists between the unrestricted double-transformation parameter relation (model 4a) and the restricted forms of this function. The likelihood ratio is defined as:

$$\phi = L(R)/L(UR)$$

where $L(R)$ is the restricted likelihood function, which corresponds to special cases of model (4a), and $L(UR)$ is the unrestricted likelihood function (model 4a). It can be shown that, given a large sample, minus two times the logarithm of the likelihood ratio is approximately distributed as chi-squared with the degrees of freedom corresponding to the number of restricted parameters.

Table 2 presents the likelihood ratio tests. The tests indicate that only the double-log hypothesis for eggs is not rejected. The double-parameter Box-Cox function represents an improvement over the single-parameter case for beef, poultry, and fish. For commodities considered here, the likelihood ratio tests reject the semi-logarithmic function, although it was preferred for food commodities by Prais and Houthakker (6). The Box-Cox curves provide a substantial improvement in statistical fit, in virtually all cases, over the more easily estimated classical functions. The double-log form appears to give the best fit among

the traditional specifications. Salathe (7) also found the double-log to be preferred for models expressing per capita expenditure as a function of per capita income.

Most commonly used significance tests, and hence confidence intervals, are based on the assumption that the regression residuals are distributed normally. Consequently, it is important that normality of the residuals be established. We tested the residuals of the alternative models for normality using the Kolmogorov-Smirnov test for goodness of fit (5). Table 3 presents the results. The test results reject normality of the residuals for the linear, semi-log, and inverse functions for all commodities considered when we postulate a homoskedastic error term *a priori*. After correction for heteroskedasticity, the test does not reject normality of the residuals for these functions. Normality of the residuals for the double-log and log-inverse functions is not rejected in all cases. This is not surprising as the double-log and log-inverse relationships correct implicitly for nonspherical residuals (8). The tests do not reject

Table 2—Tests of functional forms based on the likelihood ratio procedure¹

Model	Commodity				
	Beef	Pork	Poultry	Fish	Eggs
Linear versus double Box-Cox	102.58	98.31	95.44	73.51	75.95
Semi-log versus double Box-Cox	35.63	22.95	42.51	62.87	18.17
Double-log versus double Box-Cox	19.40	7.60	33.62	39.74	4.68
Inverse versus double Box-Cox	161.93	147.09	151.65	127.37	120.01
Log-inverse versus double Box-Cox	61.30	55.88	77.42	69.93	63.82
Single versus double Box-Cox	6.19	.02	7.63	7.74	3.21

¹The critical χ^2 value at the 0.05 significance level with two degrees of freedom is 5.99.

The Box-Cox models are superior in every case and the double-log model is close for poultry and eggs. The simulative ability of the single-parameter and double-parameter functions is almost identical, except for fish.

Table 3—Kolmogorov-Smirnov normality test

Function	Beef	Pork	Poultry	Fish	Eggs
Models uncorrected for heteroskedasticity:					
Critical value ¹	0.041	0.044	0.047	0.048	0.041
Linear	.362	.310	.271	.355	.247
Semi-log	.202	.208	.265	.362	.224
Inverse	.495	.394	.307	.470	.459
Single Box-Cox	.027	.037	.043	.038	.027
Double Box-Cox	.025	.033	.040	.032	.029
Models corrected for heteroskedasticity:					
Critical value ¹	0.041	0.044	0.047	0.048	0.041
Linear	.040	.041	.041	.047	.039
Double-log	.029	.026	.037	.030	.031
Semi-log	.039	.038	.040	.041	.028
Log-inverse	.038	.039	.032	.035	.038
Inverse	.040	.037	.044	.046	.039
Single Box-Cox	.026	.036	.042	.039	.025
Double Box-Cox	.027	.035	.038	.033	.024

¹ Critical value at the 0.05 significance level. We reject the hypothesis that the residuals are distributed normally for test statistics greater than the critical value.

normality of the residuals for both the heteroskedastic (models (4a) and (4b)) and nonheteroskedastic (models (2) and (3)) Box-Cox functions. This is also expected as the transformation parameter on the dependent variable is biased toward stabilizing the error variance in models (2) and (3), whereas models (4a) and (4b) were estimated under the assumption of a heteroskedastic error term. Clearly, stabilizing the error variance for all models is important not only to obtain reliable parameter estimates but also to establish normality of the residuals (8).

To critique the ability of the alternative models to simulate the unused sample values, we employed Theil's inequality coefficient (U). The coefficient is defined as:

$$U = \left[\sum_i (P_i - A_i)^2 / N \right]^{1/2} /$$

$$\left(\left[\sum_i P_i^2 / N \right]^{1/2} + \left[\sum_i A_i^2 / N \right]^{1/2} \right)$$

where P_i is the predicted value and A_i , the actual value. The smaller the magnitude of U, theoretically, the better a predictive model is expected. Table 4 summarizes the results. The Box-Cox models are superior in every case and the double-log model is close for poultry and eggs. The simulative ability of the single-parameter and double-parameter functions is almost identical, except for fish.

A further test of the appropriateness of a specific model is to contrast the estimated expenditure elasticities over a wide range of the data base. We divided the sample into 11 income classes from which we calculated the elasticities for the alternative models. Table 5 presents the results. The double-log function, of course, has a constant elasticity over all classes. The linear function indicates a rising elasticity; and the semi-log, log-inverse, and inverse functions indicate falling expenditure elasticities. The general behavior of the elasticities for each of the classical functional forms is uniform across commodities (6). The Box-Cox functions differ in elasticity patterns by commodity. For example, the double-parameter function shows a falling elasticity for beef, a rising elasticity for fish, and a relatively constant elasticity for pork. Clearly, the traditional forms cannot display such diverse elasticity behavior. But, if the structural characteristic of major interest is the elasticity evaluated at the sample means, the double-log function would be a reasonable alternative to the Box-Cox curves. If one's primary interest centers

Table 4—Theil inequality coefficients¹

Model	Beef	Pork	Poultry	Fish	Eggs
Linear	0.561	0.593	0.565	0.499	.0647
Semi-log	.311	.511	.583	.461	.602
Double-log	.294	.318	.275	.333	.210
Inverse	.805	.712	.754	.696	.735
Log-inverse	.603	.687	.681	.538	.705
Single Box-Cox	.201	.287	.271	.296	.209
Double Box-Cox	.199	.282	.268	.220	.208

¹ The coefficient is restricted to the (0,1) interval; zero indicates a perfect predictor.

Table 5—Expenditure elasticities over income classes¹

Commodity	Elasticities						
	Linear	Double-log	Semi-log	Inverse	Log-inverse	Single Box-Cox	Double Box-Cox
Beef income class:							
1	0.132	0.439	0.913	2.095	1.102	0.372	0.576
2	.208	.439	.768	.885	.566	.400	.529
3	.245	.439	.548	.382	.345	.411	.481
4	.297	.439	.492	.254	.256	.423	.461
5	.298	.439	.373	.146	.193	.424	.432
6	.371	.439	.391	.129	.162	.439	.429
7	.405	.439	.357	.099	.137	.445	.416
8	.492	.439	.380	.092	.119	.459	.416
9	.479	.439	.320	.067	.103	.457	.400
10	.574	.439	.346	.065	.093	.470	.402
11	.631	.439	.281	.039	.069	.477	.379
Mean	.367	.439	.436	.162	.184	.438	.431
Pork income class:							
1	.062	.211	.438	.967	.494	.173	.214
2	.090	.211	.327	.373	.255	.184	.212
3	.187	.211	.264	.183	.155	.193	.210
4	.206	.211	.306	.157	.116	.208	.219
5	.203	.211	.256	.099	.087	.212	.216
6	.301	.211	.212	.069	.073	.211	.212
7	.240	.211	.263	.072	.061	.226	.222
8	.287	.211	.184	.044	.053	.217	.210
9	.369	.211	.190	.039	.046	.224	.213
10	.370	.211	.221	.041	.042	.233	.220
11	.445	.211	.196	.027	.031	.241	.220
Mean	.218	.211	.258	.095	.082	.214	.216
Poultry income class:							
1	.066	.338	.498	1.027	.819	.322	.223
2	.160	.338	.622	.658	.423	.328	.260
3	.174	.338	.411	.263	.256	.329	.289
4	.289	.338	.505	.239	.190	.332	.311
5	.252	.338	.334	.120	.143	.331	.328
6	.312	.338	.348	.105	.121	.333	.342
7	.355	.338	.331	.084	.101	.334	.355
8	.408	.338	.333	.074	.088	.335	.366
9	.445	.338	.244	.047	.077	.334	.376
10	.476	.338	.304	.052	.069	.336	.387
11	.538	.338	.274	.035	.051	.338	.413
Mean	.304	.338	.384	.131	.107	.333	.334

See footnote at end of table.

Continued—

The double-parameter function is generally superior to the single-parameter form based on our criteria. Thus, a priori use of the classical functional forms should be reconsidered.

Table 5—Expenditure elasticities over income classes¹—Continued

Commodity	Elasticities						
	Linear	Double-log	Semi-log	Inverse	Log-inverse	Single Box-Cox	Double Box-Cox
Fish income class:							
1	0.118	0.442	0.717	1.378	0.885	0.398	0.231
2	.247	.442	.776	.768	.457	.433	.304
3	.331	.442	.630	.378	.277	.448	.364
4	.391	.442	.553	.245	.205	.456	.405
5	.406	.442	.443	.145	.155	.458	.441
6	.376	.442	.338	.096	.131	.454	.459
7	.522	.442	.393	.083	.109	.471	.502
8	.542	.442	.357	.074	.096	.473	.524
9	.608	.442	.347	.062	.082	.480	.553
10	.826	.442	.425	.069	.075	.496	.590
11	.751	.442	.285	.034	.055	.491	.638
Mean	.455	.442	.462	.147	.147	.464	.453
Eggs income class:							
1	.036	.188	.237	.532	.454	.179	.202
2	.057	.188	.191	.220	.234	.180	.195
3	.089	.188	.182	.128	.142	.181	.190
4	.130	.188	.196	.102	.105	.182	.187
5	.141	.188	.161	.063	.079	.182	.185
6	.166	.188	.160	.053	.067	.182	.183
7	.198	.188	.159	.044	.056	.183	.181
8	.227	.188	.160	.039	.049	.183	.180
9	.235	.188	.142	.030	.042	.183	.179
10	.298	.188	.164	.031	.038	.183	.178
11	.353	.188	.143	.020	.028	.184	.175
Mean	.158	.188	.172	.064	.089	.182	.183

¹Income classes are based on per capita income and arranged in ascending magnitude. Each class contains a \$500 interval. Mean income is \$2,352.83.

on total elasticity behavior or on the elasticity for a particular income group, the choice of a classical function to characterize these elasticities adequately would be inappropriate.

Comparing the single- and double-parameter Box-Cox models would appear to favor the double-parameter case for many of the commodities we considered. The single-parameter specification also limits the behavior of elasticities compared with the double-parameter model (2).

CONCLUSIONS

We have attempted to clarify the difficulties of *a priori* specification of the degree of non-linearity in an Engel curve. Likelihood ratio tests indicate rejection of all classical functional forms, except the double-log, which holds for eggs. Residual analysis has demonstrated that the assumption of approximate normality of the error term is faulty for classical functions uncorrected for heteroskedasticity. This point is

important for analysts who attempt to establish correct confidence intervals.

The ability of the alternative models to simulate the unused portion of the sample appears to favor use of the Box-Cox functions, although the double-log form is an equally good predictor in two cases. But, perhaps the clearest evidence is the behavior of the expenditure elasticities over the income classes. The traditional functions cannot match the Box-Cox curves for flexibility of elasticity behavior.

However, for elasticities evaluated at the sample means, the double-log form is an excellent alternative to the Box-Cox model.

The double-parameter function is generally superior to the single-parameter form based on our criteria. Thus, *a priori* use of the classical functional forms should be reconsidered. The rigid behavior of the traditional functions, coupled with their statistical implications, cannot match the flexibility and intuitive appeal of the Box-Cox transformed functions.

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INTERRELATED PRODUCTS AND THE EFFECTS OF AN IMPORT TARIFF

By Philip L. Paarlberg and Robert L. Thompson*

Empirical trade research devoted to national commodity policies has multiplied in recent years as more economists recognize the importance of national commodity policies on world agricultural trade. Most empirical research on trade has been confined to single-product partial equilibrium analysis, despite interrelationships among agricultural commodity markets.¹ If confined to a single-product partial equilibrium framework, analysis of changes in commodity policies will yield erroneous estimates of the magnitude of their impacts when products are interrelated. It is also possible that using a single-product partial equilibrium model may result in errors in predicting the direction of changes in endogenous variables with respect to policy changes. The final result is an important empirical issue which can affect policy recommendation.

In this article, we compare the effects of an increase in an import tariff on prices by using different models of world commodity trade to illustrate how the choice of model and the values of the parameter estimates can affect the predicted outcome. The single-product partial equilibrium model assumes that a shift in policy in one commodity market will not affect prices in any other market. In this framework, imposing an import

This article demonstrates that when a second product is introduced into the traditional single-product, partial equilibrium model, the predictions of the impact of a tariff on prices are no longer determinate. In contrast to the traditional single-product partial equilibrium framework in a two-or-more product, partial equilibrium model, an import tariff may raise, lower, or leave unchanged the price in either country examined. The empirical result depends on the relationships between own- and cross-price elasticities. The empirical example developed illustrates these relationships and shows how critical the values of own- and cross-price elasticities are to empirical policy analysis.

Keywords

*Partial equilibrium analysis
Metzler's Paradox
Cross elasticities
Import tariff
Trade policy*

tariff unambiguously lowers the price in the exporting country and raises the price in the tariff-imposing country. We contrast this result with the two-product general equilibrium model, which assumes that the prices and quantities of all products and factors are determined simultaneously. The directions of the changes in prices that result when a tariff is imposed cannot be determined *a priori* in this model.

A general equilibrium model can be cumbersome to employ in empirical research because of its

restrictive assumptions. Consequently, empirical research which takes some of the relevant simultaneities into account relies on a third framework—the multiproduct, partial equilibrium model. We demonstrate that, once the second product is added to the single-product, partial equilibrium model, a tariff's impacts cannot be determine *a priori*.

SINGLE-PRODUCT, PARTIAL EQUILIBRIUM MODEL

The most commonly used model in empirical agricultural trade research is the single-product, partial equilibrium model. This model assumes a world market for commodity *i*, which is homogeneous, that consists of two (or more) large countries which trade in a competitive market. The prices of all other commodities produced and consumed in both countries are treated as exogenous. For simplicity, it is also assumed there are no transportation or handling costs and that prices for good *i* in both regions are expressed in terms of a common currency. This model is specified as:

Country 1

$$D_{1i} = f(P_{1i}), \quad (1)$$

$$S_{1i} = g(P_{1i}), \quad (2)$$

$$X_{1i} = S_{1i} - D_{1i}, \quad (3)$$

Country 2

$$D_{2i} = h(P_{2i}), \quad (4)$$

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¹ For a review of this literature, see (12).

$$S_{2i} = k(P_{2i}), \quad (5)$$

$$M_{2i} = D_{2i} - S_{2i}, \quad (6)$$

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$$X_{1i} = M_{2i}, \quad (7)$$

$$P_{2i} = P_{1i}(1 + T_i), \quad (8)$$

where,

- D_{1i} = the quantity demanded of good i in country 1,
 S_{1i} = the quantity supplied of good i in country 1,
 X_{1i} = the quantity of good i exported by country 1,
 P_{1i} = the price of good i in country 1,
 D_{2i} = the quantity demanded of good i in country 2,
 S_{2i} = the quantity supplied of good i in country 2,
 M_{2i} = quantity of good i imported by country 2,
 P_{2i} = the price of good i in country 2,
 T_i = the *ad valorem* tariff rate on good i .

Suppose that, to satisfy pressure for protecting domestic producers of good i , country 2 raises its *ad valorem* import tariff on good i . The impacts of the increased tariff on prices in countries 1 and 2 can be determined by totally differentiating the entire model:

Country 1

$$dD_{1i} = f_i dP_{1i}, \quad (9)$$

$$dS_{1i} = g_i dP_{1i}, \quad (10)$$

$$dX_{1i} = dS_{1i} - dD_{1i}, \quad (11)$$

Country 2

$$dD_{2i} = h_i dP_{2i}, \quad (12)$$

$$dS_{2i} = k_i dP_{2i}, \quad (13)$$

$$dM_{2i} = dD_{2i} - dS_{2i}, \quad (14)$$

International Linkages

$$dX_{1i} = dM_{2i}, \quad (15)$$

$$dP_{2i} = (1 + T_i)dP_{1i} + P_{1i}dT_i. \quad (16)$$

Simplifying equations (9-14) through substitutions produces the total differentials of the excess supply and excess demand schedules:

$$dX_{1i} = (g_i - f_i)dP_{1i}, \quad (17)$$

$$dM_{2i} = (h_i - k_i)dP_{2i}. \quad (18)$$

Using the international linkages, (15) and (16), and solving for the change in price in country 1 (the exporter) resulting from a change in the tariff rate, dP_{1i}/dT_i yields:

$$\begin{aligned} dP_{1i}/dT_i &= (h_i - k_i)P_{1i}/ \\ &(g_i - f_i) - (h_i - k_i)(1 + T_i). \end{aligned} \quad (19)$$

Solving for the price change in country 2 resulting from a change in the import tariff rate, dP_{2i}/dT_i , results in:

$$\begin{aligned} dP_{2i}/dT_i &= (g_i - f_i)P_{1i}/ \\ &(g_i - f_i) - (h_i - k_i)(1 + T_i). \end{aligned} \quad (20)$$

The direction of the change in prices resulting from an increase in the import tariff can be determined. We can find the direction if we assume that demand schedules slope downward and supply schedules have a positive slope—that is, f_i and h_i are negative, and g_i and k_i are positive. It is also assumed that $T_i \geq 0$, and $P_{1i} > 0$. The numerator of equation (19) is unambiguously negative, while the denominator is positive. Therefore, $dP_{1i}/dT_i < 0$; an increase in the import tariff unequivocally lowers the price of good i in the exporting country. In equation (20) the numerator and the denominator are positive. Consequently, $dP_{2i}/dT_i > 0$, or an increase in the import tariff raises the price of i in country 2 and protects producers of i in the country imposing the tariff.

Therefore, when analyzing the impacts of an increase in an import tariff using the single-product, partial equilibrium model, one always obtains unambiguous results. The price of the commodity in the exporting country declines when the tariff is increased, while the price in the importing country rises to protect domestic producers of good i .

THE METZLER PARADOX

Whereas most empirical research on trade relies on the approach just discussed, international trade theory is based principally on the two-product, general equilibrium model. The one-product model treats one good in an economy of n goods, whereas the simple two-product, general equilibrium model assumes those two products represent all goods produced and consumed in the economy. The one-product, partial equilibrium model abstracts from all factor market adjustments by assuming that producing the product consumes such a small fraction of each factor that the industry is in effect a price taker in all factor markets. The general equilibrium model assumes that two factors are used in producing the two products, that they are allocated to equate the values of their marginal products in both uses, and that both are always fully employed. Any change in the volume of either good produced changes the price of both factors, which shifts the supply schedules of both goods and changes the income of the factor owners.

The one-good, partial equilibrium model also assumes that expenditures on the product represent an imperceptibly small fraction of consumer income. Therefore, any change in the quantity of the product purchased will not affect the quantities or prices of any other products purchased. The general equilibrium model, in contrast, assumes both goods are "large" components of consumer expenditures, and anything, such as a tariff, which alters consumption of one product

shifts the demand curve for the other product as well. This changes its price and shifts the demand schedule for the product on which the tariff is imposed.

For each country, the two-product, general equilibrium model contains linear homogeneous production functions for the two goods. Assumptions include given endowments of two factors of production, full employment conditions, four marginal productivity conditions which state that the value of the marginal product of each factor in each use must equal its price, and a demand system which ensures that all income is spent on the two goods.

In 1949, Metzler illustrated that in the two-product, general equilibrium model, the signs of the tariff impacts illustrated above in the single-product, partial equilibrium model are no longer unambiguous. He showed that in the two-sector, general equilibrium model an import tariff could lower the relative price of the import good in the tariff-imposing country under certain circumstances (7).

Assume that country 2 imposes an *ad valorem* import tariff on good i and redistributes the tariff revenue to consumers in country 2 as a lump sum income subsidy. The impact of the tariff can be found by treating the two-product, general equilibrium model like that discussed earlier in the single-product, partial equilibrium model. The first step is to reduce the model to its offer curves, which are the general equilibrium analogs of the excess demand and excess supply schedules in the partial equilibrium framework. Taking

the total differential of the system and solving for the change in relative prices with respect to the tariff results in the following equation:²

$$\frac{d(P_i/P_j)}{dT_i} = \frac{(e_1 + m_2 - 1)(P_i)}{(e_1 + e_2 - 1)(P_j)}, \quad (21)$$

where:

- e_1 = country 1's general equilibrium elasticity of import demand (defined as a positive value),
- e_2 = country 2's general equilibrium elasticity of import demand (defined as a positive value),
- m_2 = country 2's marginal propensity to spend income on its import good (i).
- $(m_2 - 1)$ = country 2's marginal propensity to spend income on its export good (j).

The Marshall-Lerner condition, the stability condition of the gen-

² See (3, pp. 247-249) for the complete derivation of (21). Derivations can also be found in (11, pp. 240-243) or (4, pp. 473-480).

eral equilibrium system, states that the sum of the import demand elasticities must exceed unity; that is, $e_1 + e_2 > 1$. Therefore, if the market is stable, the denominator of (21) is positive. The numerator of (21) is divided into a price effect, e_1 , and a real income effect, $(m_2 - 1)$. The import tariff imposed by country 2 raises the relative price of good i to its consumers through the price effect. However, this lowers their real income; thus, the income effect offsets part of the increase in the relative price of good i . This is reinforced as part of the tariff revenue collected on imports of good i is spent by consumers on good j , $(m_2 - 1)$. The normal result is for $e_1 + m_2 > 1$ and for the numerator thereby to be positive. A tariff on good i then protects its producers, $d(P_i/P_j)/dT_i > 0$.

Metzler's contribution was to demonstrate that this result need not necessarily hold. Suppose demand for good i in country 1 is extremely inelastic, that is, e_1 is very small. Then the tariff on good i could lower its relative price, in effect failing to protect producers. For this to occur, for the numerator of (21) to be negative, the marginal propensity to spend income on its import good, m_2 , must be low. Since $m_1 + m_2 = 1$, the marginal propensity to spend income on its export good j , $(m_2 - 1)$, must be relatively high. Under these conditions, if $e_1 < m_2 - 1$, the shift in demand in favor of j is strong enough to swamp the price effects of the tariff, and the relative price of i in the tariff-imposing country declines. Thus, predicting even the

direction of the price effects of a tariff is an empirical issue. Unless we can estimate the magnitude of the elasticity of demand for imports by country 1 and the marginal propensity to spend income on the import good, the impact of a tariff on good i cannot be determined *a priori*.

To apply the two-sector, general equilibrium model, one must be able to aggregate all goods into two product groups, for example, agricultural products versus all other goods, and all countries into two regional aggregates, for example, the United States versus the Rest-of-the-World. One should also recognize that the model assumes full employment of both factors of production. Difficulties in product aggregation and the full-employment assumption tend to make this model intractable for empirical work, although it remains a useful theoretical tool. Moreover, the analyst often wants more specific product disaggregation than the set of all agricultural products. Therefore, to analyze trade issues with interrelated products, the analyst must employ a two-or-more-commodity, partial equilibrium model.

TWO-PRODUCT, PARTIAL EQUILIBRIUM MODEL

In this section, we show that the general equilibrium income effect is not the only influence that can produce an indeterminate solution. One can also occur when the partial equilibrium model is expanded to include more than one product, because of the cross-price effects which are introduced (2, 9).

Assume for simplicity two countries trade two commodities which are imperfect substitutes for one another and whose prices and quantities are not determined simultaneously with those of other goods in the economy.

Let the model be:

Country 1

$$D_{1i} = f(P_{1i}, P_{1j}), \quad (22)$$

$$S_{1i} = g(P_{1i}, P_{1j}), \quad (23)$$

$$X_{1i} = S_{1i} - D_{1i}, \quad (24)$$

$$D_{1j} = a(P_{1j}, P_{1i}), \quad (25)$$

$$S_{1j} = b(P_{1j}, P_{1i}), \quad (26)$$

$$X_{1j} = S_{1j} - D_{1j}, \quad (27)$$

Country 2

$$D_{2i} = h(P_{2i}, P_{2j}), \quad (28)$$

$$S_{2i} = k(P_{2i}, P_{2j}), \quad (29)$$

$$M_{2i} = D_{2i} - S_{2i}, \quad (30)$$

$$D_{2j} = c(P_{2j}, P_{2i}), \quad (31)$$

$$S_{2j} = w(P_{2j}, P_{2i}), \quad (32)$$

$$M_{2j} = D_{2j} - S_{2j}, \quad (33)$$

International Linkages

$$X_{1i} = M_{2i}, \quad (34)$$

$$X_{1j} = M_{2j}, \quad (35)$$

$$P_{2i} = P_{1i}(1 + T_i), \quad (36)$$

$$P_{2j} = P_{1j}(1 + T_j). \quad (37)$$

Assume country 2 levies an *ad valorem* import tariff on good *i*, but does not change its policy on good *j*. Totally differentiating the system of equations and reducing the number of equations by substitutions produces the differentials of the excess demand and excess supply schedules:

$$dX_{1i} = (g_i - f_i)dP_{1i} + (g_{ij} - f_{ij})dP_{1j}, \quad (38)$$

$$dX_{1j} = (b_j - a_j)dP_{1j} + (b_{ji} - a_{ji})dP_{1i}, \quad (39)$$

$$dM_{2i} = (h_i - k_i)dP_{2i} + (h_{ij} - k_{ij})dP_{2j}, \quad (40)$$

$$dM_{2j} = (c_j - w_j)dP_{2j} + (c_{ji} - w_{ji})dP_{2i}. \quad (41)$$

Using the international quantity linkages to equate (38) to (40), and (39) to (41) yields:

$$(g_i - f_i)dP_{1i} + (g_{ij} - f_{ij})dP_{1j} = (h_i - k_i)dP_{2i} + (h_{ij} - k_{ij})dP_{2j}, \quad (42)$$

$$(b_j - a_j)dP_{1j} + (b_{ji} - a_{ji})dP_{1i} = (c_j - w_j)dP_{2j} + (c_{ji} - w_{ji})dP_{2i}. \quad (43)$$

Substituting the international price linkages for dP_{2i} and dP_{2j} , rearranging, and simplifying yields two equations:

$$AdP_{1i} + BdP_{1j} = CdT_i + DdT_j, \quad (44)$$

$$EdP_{1i} + FdP_{1j} = GdT_i + HdT_j, \quad (45)$$

where:

$$\begin{aligned} A &= (g_i - f_i) - (h_i - k_i)(1 + T_i), \\ B &= (g_{ij} - f_{ij}) - (h_{ij} - k_{ij})(1 + T_j), \\ C &= (h_i - k_i)P_{1i}, \\ D &= (h_{ij} - k_{ij})P_{1j}, \\ E &= (b_{ji} - a_{ji}) - (c_{ji} - w_{ji})(1 + T_i), \\ F &= (b_j - a_j) - (c_j - w_j)(1 + T_j), \\ G &= (c_{ji} - w_{ji})P_{1i}, \\ H &= (c_j - w_j)P_{1j}. \end{aligned}$$

The supply and demand schedules are assumed to be well behaved, such that, for the demand schedules, the own-price partial derivatives are negative, $f_i, h_i, a_j, c_j < 0$, while for the supply functions the direct partials are positive; that is, $g_i, k_i, b_j, w_j > 0$. Commodity *j* is assumed to be an imperfect substitute for good *i* in both demand and supply. If the share of expenditure on both goods is low, the income effect will not outweigh the substitution effect in the Slutsky condition, and the cross price effects in demand are positive that is; $f_{ij}, h_{ij}, a_{ji}, c_{ji} > 0$. The two products are assumed to compete for the same inputs so that, in the supply functions, a negative relationship between the changes in quantity of one good supplied and the price of a sub-

stitute good is expected; that is, $g_{ij}, k_{ij}, b_{ji}, w_{ji} < 0$. Given these expected signs on the partial derivatives, the signs of A to H can be determined:

$$\begin{aligned} A &> 0 & E &< 0 \\ B &< 0 & F &> 0 \\ C &< 0 & G &> 0 \\ D &> 0 & H &< 0 \end{aligned}$$

The system of two equations, (44) and (45), has two unknowns, dP_{1i} and dP_{1j} , and the equations can be solved using Cramer's Rule. Recall that it is assumed that $dT_j = 0$; hence,

$$\frac{dP_{1i}}{dT_i} = \frac{CF - GB}{AF - EB}, \quad (46)$$

$$\frac{dP_{1j}}{dT_i} = \frac{AG - CE}{AF - EB}. \quad (47)$$

The changes in prices resulting from the increase in the tariff on good *i* can be evaluated based on the signs of A to H assigned above. In (46) the signs of both numerator and denominator are indeterminate. The denominator, $AF - EB$, is the difference between two positive values, AF and EB . AF is composed of all the own-partial derivatives, whereas EB is composed solely of cross-price partial derivatives. Hence, the sign of the denominator depends on the relative strengths of the own- and cross-price effects. The numerator, $CF - GB$, is the difference between two negative values, CF and GB ; hence, its sign is also indeterminate. CF consists

of the own-partial derivatives, whereas GB contains cross-partial derivatives. Thus, if all the cross-partial derivatives are less than the own-partial derivatives, the denominator will be positive and the numerator will be negative. Hence, the tariff would lower the exporter's price. This is the normally expected result.

However, closer inspection of the terms shows that it is theoretically possible for the exporter's price of the good on which the tariff is imposed to rise. In the numerator, $(g_i - f_i)$ and $(b_{ji} - a_{ji})$ are omitted, while they appear in the denominator. Consequently, if the own-price effects for good i in country 1 are low while the cross-price effects in country 1's market for good j are strong, both numerator and denominator could be negative and a perverse (positive) result could occur.

Similarly, in (47) the signs of both numerator and denominator are indeterminate. The denominator is the same as in (46) as has been shown. The numerator, $AG - CE$, is the difference between two positive numbers, AG and CE . Therefore, the sign of the numerator of (47) is also ambiguous. Examining the numerator shows that AG and CE both include own-partial and cross-partial derivatives. Consequently, no *a priori* basis exists for determining the impact of a tariff levied against i on the price of good j in country 1.

Returning to equations (42) and (43), and substituting the international price linkages for dP_{1i} and dP_{1j} , the change in country 2's prices resulting from an increase in the import tariff can be determined.

$$\frac{A'dP_{2i} + B'dP_{2j}}{C'dT_i + D'dT_j} = \quad (48)$$

$$\frac{E'dP_{2i} + F'dP_{2j}}{G'dT_i + H'dT_j} = \quad (49)$$

where:

$$A' = \frac{(g_i - f_i) - (h_i - k_i)}{(1 + T_i)} > 0,$$

$$B' = \frac{(g_{ij} - f_{ij}) - (h_{ij} - k_{ij})}{(1 + T_j)} < 0,$$

$$C' = \frac{(g_i - f_i)P_{1i}}{(1 + T_i)} > 0,$$

$$D' = \frac{(g_{ij} - f_{ij})P_{1j}}{(1 + T_j)} < 0,$$

$$E' = \frac{(b_{ji} - a_{ji}) - (c_{ji} - w_{ji})}{(1 + T_i)} < 0,$$

$$F' = \frac{(b_j - a_j) - (c_j - w_j)}{(1 + T_j)} > 0,$$

$$G' = \frac{(b_{ji} - a_{ji})P_{1i}}{(1 + T_i)} < 0,$$

$$H' = \frac{(b_j - a_j)P_{1j}}{(1 + T_j)} > 0.$$

Still assuming $dT_j = 0$, and solving by Cramer's Rule produces:

$$\frac{dP_{2i}}{dT_i} = \frac{C'F' - G'B'}{A'F' - B'E'}, \quad (50)$$

$$\frac{dP_{2j}}{dT_i} = \frac{A'G' - C'E'}{A'F' - B'E'}. \quad (51)$$

In equations (50) and (51), the signs of both the numerators and denominators are indeterminate. The denominators of both (50) and (51) are the positive product composed of cross-partial derivatives, $B'E' > 0$, subtracted from the positive product composed of direct partial derivatives, $A'F' > 0$. The result is an indeterminate sign of the denominator for both price changes.

The numerator of (50) is the difference between two positive terms, $C'F'$ and $G'B'$. Hence, its sign is indeterminate. The numerator includes neither the direct partial derivatives from country 2's market for i , $(h_i - k_i)$, nor the cross partials from country 2's market for j , $(c_{ji} - w_{ji})$. The expected result based on the single-product partial equilibrium model is that the price of good i in country 2 will rise as a result of its imposing an import tariff on i . If, however, the own-price effects in country 2's market for i are low and the cross-price effects for good i are large, the denominator may be negative, while the numerator remains positive. In this case the tariff could lower the price of good j are large, tariff-imposing country, and thereby produce a paradoxical result similar to Metzler's, but with no income effect.

In equation (51), the numerator is the difference between two negative terms. $A'G'$ and $C'E'$ are composed of own- and cross-partial derivatives and their signs also cannot be determined *a priori*.

Despite the absence of the general equilibrium income effects necessary for the Metzler paradox, the indeterminate result can be obtained in the two-product, partial equilibrium model. When the model is expanded beyond two commodities, this indeterminate solution occurs under increasingly less severe conditions.

AN EMPIRICAL COMPARISON OF THE ONE- AND TWO-PRODUCT, PARTIAL EQUILIBRIUM MODELS

Based on the theoretical development of the single-product, partial equilibrium model and the two-product, partial equilibrium model, two potential sources of error may enter into the analysis. First, if we assume the markets are interrelated, using the single-product model will bias the predicted magnitude of impacts from the import tariff and may result in erroneous predictions of the direction of price changes. Second, the empirical estimates of the elasticities used in the analysis are of critical importance. If the quality of the estimates is in doubt, the researcher should evaluate carefully the effects of errors through sensitivity analysis of the relative size of the elasticities.

In this section, we make two comparisons. We compare the price impacts of a tariff on one good using the one- and two-product, partial equilibrium models to illustrate the conclusions reached

above. Because a wide range of elasticity estimates exists in the literature, particularly for cross-price effects, these calculations are made using two different elasticity sets.

For this illustration, we use the world wheat and coarse grains markets. Assume the world market for grain is divided into two regions, the United States and the Rest-of-the-World (ROW), where the United States exports both wheat and coarse grains to the Rest-of-the-World. Suppose a policymaker wants to know the impact of a 20-percent increase in an *ad valorem* wheat import tariff levied by the Rest-of-the-World.³

One set of regional longrun demand and supply elasticities for grains is presented in (10). Weighting the regional elasticities based on 1975 to 1979 average regional shares of world wheat and coarse grains supply and disappearance (table 1), we derive the internal demand and supply elasticities for the Rest-of-the-World (table 2), which provide the partial derivatives shown in table 4 as estimate 1.

A second set of elasticity estimates is available from econometric estimation done by the U.S. Department of Agriculture on the

Cross Commodity Model.⁴ While (10) shows the cross-price elasticities considerably smaller than the own-price elasticities, these results show much larger cross-price effects relative to the own-price effects. For example, the Cross Commodity Model reports an own-price elasticity of export demand for U.S. wheat of -0.481 ; however, the cross elasticity for the price of feed grains is 0.854 . Several other examples of large cross-price elasticities and low own-price elasticities can also be found in that model. This suggests that the choice of elasticities can yield considerably different conclusions regarding the impact of a tariff.

This problem emphasizes the need for sensitivity analysis. To illustrate, we present a second set of elasticities for the Rest-of-the-World in table 3 which have relatively higher cross-price elasticities as implied by the Cross Commodity Model.⁵ The own-price elasticities for wheat in the Rest-of-the-World are more inelastic. The demand elasticity is changed from -0.25 to -0.2 , while the supply elasticity is lowered from 0.25 to 0.1 . The cross-price elasticities for wheat relative to the coarse grains price are raised to levels exceeding the own-price elasticities to be consis-

³ Tariffs are not the main protectionist device in the world wheat market; most importers rely instead on nontariff barriers. The 20-percent import tariff used in this analysis can be interpreted as the tariff equivalent of a nontariff barrier for purposes of illustration. The "Rest-of-the-World" is an aggregate region consisting of importers and non-U.S. exporters with existing trade barriers.

⁴ Copies of the current status of the model can be obtained from the National Economics Division, ESS.

⁵ The elasticities shown in table 3 are not those in the Cross Commodity Model, but are hypothetical elasticities calculated by the authors to illustrate the implications of relatively higher cross elasticities as implied by the estimates in the Cross Commodity Model.

Table 1—World wheat and coarse grains supply and utilization balances,
1975/79 average

Item	Wheat	Coarse grains
<i>Million metric tons</i>		
United States:		
Beginning stocks	23.05	26.02
Production	55.12	200.20
Supply	78.17	226.22
Exports	30.42	51.52
Use	21.60	138.60
Ending stocks	26.40	33.68
Demand	48.00	172.28
Rest-of-the-World:		
Beginning stocks	52.70	43.18
Production	341.62	500.80
Supply	394.32	543.98
Imports	30.42	51.52
Use	364.82	552.65
Ending Stocks	59.68	45.30
Demand	424.50	597.95
<i>Real dollars</i>		
Price per ton	103.94	81.12

Source: (13)

Table 2—Internal longrun demand and supply price elasticities for
wheat and coarse grains

Region and commodity	Demand price		Supply price	
	Wheat	Coarse grains	Wheat	Coarse grains
<i>Elasticity</i>				
United States:				
Wheat	-0.20	0.10	0.20	-0.15
Coarse grains	.10	-.40	-.05	.30
Rest-of-the-World:				
Wheat	-.25	.10	.25	-.06
Coarse grains	.10	-.35	-.05	.31

Source: Based on (10).

tent with the relationships of the econometric estimates, both cross elasticities are set at 0.3 in absolute value. In the coarse grains market in the Rest-of-the-World, the cross-price elasticities are raised to levels slightly below the own-price elasticities both 0.3 in absolute value. None of these changes in elasticities exceeds the magnitude of changes that a researcher may experience during econometric estimation, and none of their values lies outside the range one might expect *a priori*. The associated partial derivatives are presented in table 4 as estimate 2.

The change in prices resulting from a change in the import tariff in the single-product, partial equilibrium model are shown by equations (19) and (20) for the exporting and importing countries, respectively. In the two-product, partial equilibrium model, changes in the prices of the two commodities in the exporting country are derived from equations (46) and (47). In the importing country, the price changes resulting from the tariff change are shown in equations (50) and (51). The two sets of partial derivative estimates contained in table 4 (estimates 1 and 2, respectively), are substituted into (19), (20), (46), (47), (50), and (51) to calculate the price changes resulting from a 20-percent increase in the Rest-of-the-World wheat tariff. Table 5 contains the price changes under the two sets of elasticities.

Under the first set of elasticities, in which the cross-price elasticities for both coarse grains and wheat are considerably smaller than the own-price elasticities, the price

Table 3—Alternative set of price elasticities for wheat and coarse grains¹

Region and product	Demand price		Supply price	
	Wheat	Coarse grains	Wheat	Coarse grains
<i>Elasticities</i>				
United States:				
Wheat	−0.2	0.10	0.20	−0.15
Coarse grains	.1	−.40	−.05	.30
Rest-of-the-World:				
Wheat	−.2	.30	.10	−.30
Coarse grains	.3	−.35	−.30	.31

¹ These elasticities are not the set used in the Cross Commodity Model of the National Economics Division, ESCS, but rather are hypothetical elasticities calculated by the authors to illustrate the implications of relatively higher cross elasticities which are implied by estimates in that model.

Table 4—Partial derivatives calculated from price elasticities¹

Item	Wheat market			Coarse grains market		
	Variable	Estimate 1	Estimate 2	Variable	Estimate 1	Estimate 2
<i>Derivatives</i>						
United States:						
Demand	f_i	−0.0924	−0.0924	a_j	−0.8495	−0.8495
	f_{ij}	.0592	.0592	a_{ji}	.1657	.1657
Supply	g_i	.1504	.1504	b_j	.8366	.8366
	g_{ij}	−.1445	−.1445	b_{ji}	−.1088	−.1088
Rest-of-the-World:						
Demand	h_i	−1.021	−.8168	c_j	−2.5799	−2.5800
	h_{ij}	.5233	1.5700	c_{ji}	.5733	1.7260
Supply	k_i	.9484	.3794	w_j	2.0788	2.0788
	k_{ij}	−.2917	−1.4580	w_{ji}	−.2617	−1.5700

¹ Based on tables 1, 2, and 3.

Table 5—Price impacts of a 20-percent import tariff on wheat in one- and two-product, partial equilibrium models, alternative elasticity assumptions

Product/region	First set of elasticities		Second set of elasticities	
	One-product model	Two-product model	One-product model	Two-product model
<i>Dollars/metric ton</i>				
Wheat:				
United States	-18.51	-18.75	-17.28	-26.41
Rest-of-the-World	+2.38	+2.03	+3.51	-5.64
Coarse grains:				
United States	—	-.54	—	-4.07
Rest-of-the-World	—	-.54	—	-4.07

— = not applicable.

impacts of the wheat tariff in the one-product and two-product models are nearly identical. In the single-product model, the tariff on wheat lowers the U.S. wheat price by \$18.51 per ton. When the coarse grains market is added to the model, the import tariff lowers U.S. prices by \$18.75 per ton, or \$0.24 per ton more than in the single-product model. Similarly, in the Rest-of-the-World, the tariff raises the wheat price by \$2.38 per ton if the single-product model is used, and by \$2.03 per ton with the two-product model. The small magnitudes of the cross elasticities result in only a decline of \$0.54 per ton in coarse grain prices because of the wheat tariff.

Little difference exists in the predictions of the one- and two-product models. These results may appear to suggest that little reason exists not to conduct tariff analysis one product at a time. However, these results depend on the rela-

tively low cross-price effects in the first set of elasticities.

The second set of elasticities used for illustration exhibits a pattern of much larger cross-price effects and somewhat smaller own-price elasticities. Repeating the calculations of the effect of a tariff on wheat under the two models with this second set of elasticities results in considerably different predicted impacts on wheat and coarse grain prices. In this case the single-product model predicts a decline in the U.S. wheat price of \$17.28 per ton resulting from the 20-percent wheat tariff. When the analysis is performed with the two-product model, the predicted price decline is \$26.41 per ton, or \$9.13 per ton more than the decline forecast by the single-product model. Because of the relatively large cross-price effects, if the researcher relied on the single-product model in this case, the forecast decline in the price of wheat in the United States

would be underestimated by 9 percent.

The effect of the tariff on prices in the Rest-of-the-World (table 5) shows an even more serious difficulty. The single-product model predicts that wheat producers in the Rest-of-the-World receive protection from the wheat import tariff through a price increase of \$3.51 per ton. However, the two-product, partial equilibrium model predicts that the wheat price in the Rest-of-the-World *declines* \$5.64 per ton. Thus, the relatively large cross-price elasticities in the second set of elasticities produces an effect analogous to the Metzler paradox in the general equilibrium model. The imposition of the tariff on wheat by the importing country lowers the price of wheat in that country, consequently injuring its producers who had pressed for the tariff protection.

The paradoxical result occurs because the own-price effects dominate the cross-price effects in the numerator of equation (50), but the low own-price elasticities for wheat in the Rest-of-the-World and the high cross-price elasticities reverse the sign of the denominator.

Had the researcher relied on the single-product model using the second set of elasticities for the analysis, the conclusions on the price impacts of the wheat tariff would have been in error. The decline in U.S. wheat prices would be underestimated by \$9 per ton. The price of wheat in the Rest-of-the-World would decline by \$5.64 per ton, rather than rising by \$3.51 per ton. This illustrates that when large cross-price effects exist, the analyst must use the two-product

The researcher can use sensitivity analysis to evaluate the effect of differing sets of elasticities on the magnitude and direction of impacts, particularly when the researcher doubts the quality of the empirical estimates.

model. The difference in results from the two different elasticity sets clearly demonstrates the need for good quality estimates not only of the relevant own-price effects but also of the cross-price effects.

CONCLUSIONS

When the traditional single-product partial equilibrium model is expanded to include other products, the estimated signs of the impacts of a policy shift are indeterminate and depend on the relative sizes of the own- and cross-price elasticities. In the single-product, partial equilibrium model an import tariff unambiguously lowers prices in the exporting country, while protecting producers in the importing country through higher prices. The two-product, general equilibrium model shows that changes in real income in the tariff-imposing country may contradict the determinate results of the single-product, partial equilibrium model. Despite the absence of real income effects in the two-product, partial equilibrium model, the indeterminate results of the general equilibrium model may hold because of cross-price effects. When these are relatively large, the single-product model's estimates of the magnitudes of impacts from tariff will be inaccurate at best and may err in predicting the direction of the effects.

The empirical examples illustrate why these theoretical conclusions are important for policy researchers. The net impacts of a policy depend on the relative size of the cross elasticities. When the cross elasticities are relatively low, errors

associated with using a single-product, partial equilibrium model are small, as in the case of the first set of elasticities. If, however, the cross-price effects are large relative to the own-price effects, as in the second scenario, using the single-product model will lead to errors of magnitude, and in this example, a further error occurs in predicting the direction of the price changes.

Given the importance of the cross-price elasticities to the predictions, the quality of the estimates is critical. Yet, cross-price effects are often treated as a secondary concern by researchers. Variables known to be relevant are often omitted because they are statistically insignificant or have the "wrong" sign when regressions are run. Often researchers do not scrutinize their values for plausibility.

Our analysis shows that the researcher involved in policy research must carefully evaluate the relationships among the price elasticities in the model. The researcher can use sensitivity analysis to evaluate the effect of differing sets of elasticities on the magnitude and direction of impacts, particularly when the researcher doubts the quality of the empirical estimates.

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THE FOOD STAMP PROGRAM AND LOW-INCOME HOUSEHOLDS' FOOD PURCHASES

By Larry E. Salathe*

The Food Stamp Program is intended to supplement the food budgets of low-income households. The purpose of this article is to analyze how food stamp recipients use their increased buying power—the types of food items they buy and the types they avoid—as compared with low-income households who do not participate in the program. The study provides a base for assessing the impact of eliminating the purchase requirement (as of January 1, 1979) when new data on food purchases by food stamp households become available.

The latest period for which data are available for this analysis is 1972-74. Since that period, the Food Stamp Program has undergone major change. During 1972-74, qualified households received an allotment of food coupons based on the number of persons in the household; the recipient paid an amount (the purchase requirement) for the allotment based on the net total income of the household. The difference between the purchase requirement and the value of the food coupon allotment was referred to as the "bonus" or the value of "free" coupons received. On January 1, 1979, the purchase requirement was eliminated.¹ Now, qualified households receive an allotment of food coupons equal

Households participating in the Food Stamp Program increased their food expenditures an average of 10 percent. Their food-at-home expenditures rose 19 percent while food-away-from-home expenditures declined 36 percent. Increases occurred for cereal and dairy products, eggs, nonalcoholic beverages, pork, poultry, and processed vegetables. The Food Stamp Program was estimated to be nearly three times as effective as a cash transfer program in expanding food purchases. These conclusions are based on an analysis of the 1972-74 Bureau of Labor Statistics Consumer Expenditure Survey, when the purchase requirement was in effect.

Keywords

*Food expenditures
Food Stamp Program
Household income*

in value to the bonus. Economic theory indicates that this change has reduced the program's ability to expand food purchases per dollar distributed as it permits participants to spend more of their income on nonfood items (3).²

DATA SOURCE

Data for this analysis are from the 1972-74 Bureau of Labor Statistics (BLS) Consumer Expenditure Diary Survey (CEDs). The CEDs data were collected in two 12-month periods (6). Data on

² Italicized numbers in parentheses refer to References at the end of this article.

participation in the Food Stamp Program were collected only in the second of these periods. In that second survey, 10,650 households provided complete information on income and food purchases. A total of 610 of these households (5.7 percent) participated in the Food Stamp Program.³ Of those, 53 households were eliminated from the study because (1) the household did not provide information on the value of food coupons received or on the (purchase requirement) amount paid to obtain the food coupons, or (2) the household's recorded before-tax income for the previous year exceeded twice the maximum income eligibility standard in effect during 1973-74. The second criterion was used to eliminate households whose income status seemed to have changed dramatically between the previous year and the time they were surveyed.

Food stamp recipients had an average before-tax household income of \$3,424, whereas all households in the survey had an average before-tax income of \$11,295. As past studies have indicated that income influences food purchases, a subsample of nonparticipants was selected with incomes similar to those of Food Stamp Program participants. Income eligibility standards for the Food Stamp Pro-

³ A disproportionate number of food stamp households did not provide data on their incomes. In the original sample, there were a total of 12,121 households, of which 826 participated in the Food Stamp Program. In 1974, about 9 percent of all U.S. households participated in the Food Stamp Program.

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¹ The impact of eliminating the purchase requirement on participants' food purchases is beyond the scope of this article, and the results presented do not apply directly to the current Food Stamp Program.

gram in effect from July through December 1973 for the 48 contiguous States and the District of Columbia were used as the selection criteria:

Household size	Monthly income
	<i>Dollars</i>
1	183
2	240
3	313
4	387
5	460
6	533
7	600
8	667
Each additional member	53

The income eligibility standards were raised 20 percent to account for deductions (such as excessive housing and medical costs) that are subtracted from a household's income when determining eligibility for Food Stamp Program benefits (see (7), Title XIII).⁴ Using these income criteria, 1,697 households could have participated in the Food Stamp Program, but did not.

The average weekly per capita (before-tax) income of eligible nonparticipants was \$27.23, while that of participants averaged \$24.20. In addition, participants received, on average, a net transfer of \$4 per person per week from the Food Stamp Program.

Generally, eligible nonparticipant households were smaller and had older members than did partici-

pant households. The average household size was 2.87 members for eligible nonparticipants and 3.4 members for participants. Of all eligible nonparticipant household members, 14 percent were under 10 years of age, while 32 percent were over 65 years of age.⁵ In comparison, 24 percent of all participant household members were under 10 years of age, and only 19 percent were over 65 years of age. One-fifth of all eligible nonparticipant households were black, while two-fifths of all participant households were black.

METHODOLOGY

Differences in food purchasing behavior between participants and eligible nonparticipants may be attributable to differences in racial mix, household size and composition, and other socioeconomic and demographic characteristics. Traditionally, researchers have attempted to isolate the impact of the Food Stamp Program by specifying a functional relationship among household food expenditures, household characteristics, and the bonus value of food stamps received. In this traditional approach, the relationship between food expenditures and income for participant households is assumed continuous. Alternatively, the impact of a dollar of bonus food stamps on household food purchases is assumed either as not varying as income rises or as declining monotonically as income increases.

A theoretical model developed by the author (3) indicates that this relationship is discontinuous, which could lead to inaccurate estimates of the program's impacts. Accounting for the discontinuity statistically requires identifying participant households who spend no more than the value of food stamps received on food at home. Existing household survey data, however, do not contain the information required to identify these households. Therefore, an alternative procedure was used to isolate the impact of the Food Stamp Program on household food expenditure behavior (see (3)).

The first step consisted of estimating the functional relationship between the food expenditures and household characteristics of eligible nonparticipant households. The second step used the estimated relationships in the first step to derive estimates of eligible nonparticipants' food expenditures, assuming they possess the same characteristics as participant households. The difference between food expenditures of participants and eligible nonparticipants after adjusting for differences in household characteristics can then be used to measure the impact of the Food Stamp Program on food expenditure behavior.

ECONOMETRIC MODEL

Least squares regression was used to estimate the functional relationship between household food expenditures and household characteristics for eligible nonparticipants. The general form of the model was:

⁴ Survey data were insufficient to determine the actual value of deductions or food stamp eligibility based upon asset criteria.

⁵ Asset criteria may have eliminated the eligibility of some households with members over 65 years of age.

$$E_{ih} = E_{ih} (\text{URBN}_h, \text{NE}_h, \text{NC}_h, S_h, \text{WHT}_h, \text{PY}_h, \text{NAG1}_h, \text{NAG2}_h, \text{NAG4}_h, \text{NAG5}_h, \text{NAG6}_h, \text{LNFMS}_h) \quad (1)$$

where:

E_{ih} = per capita weekly household expenditures on food group i by the h th household,

URBN_h = 1 if the h th household's residence is urban, 0 otherwise,

NE_h = 1 if the h th household's residence is in the Northeastern region, 0 otherwise,

NC_h = 1 if the h th household's residence is in the North Central region, 0 otherwise,

S_h = 1 if the h th household's residence is in the Southern region, 0 otherwise,

WHT_h = 1 if the h th household's head is not black, 0 otherwise,

PY_h = per capita weekly before-tax income of the h th household,

NAG1_h = proportion of members in the h th household under 11 years of age,

NAG2_h = proportion of members in the h th household between 11 and 20 years of age,

NAG4_h = proportion of members in the h th household between

36 and 50 years of age,

NAG5_h = proportion of members in the h th household between 51 and 65 years of age,

NAG6_h = proportion of members in the h th household over 65 years of age, and

LNFMS_h = natural logarithm of the h th household's size.

The specification of this relationship was motivated by previous studies analyzing household expenditure behavior.⁶ The relationship expresses per capita weekly household expenditures as a function of per capita weekly income, race, region, urbanization, and household size and composition. The natural logarithm of household size was included to allow for economies of size in food purchasing.

The matrix of explanatory variables would be singular if all urbanization, race, region, and age categories were included in the specification. The excluded or base categories include: in the urbanization category, nonurban; in the region category, the western; in the racial category, black; and in the age category, 21 through 35 years. Thus, the coefficients of the included urbanization, race, region, and age categories denote the change in per capita food expenditures relative to the particular excluded category. For example, the coefficient of NAG4 denotes

the difference in per capita household food purchases if all household members were 36 through 50 years of age rather than 21 through 35 years of age.

Table 1 presents the estimated expenditure relationships. These relationships indicate that household characteristics are important in explaining household food purchase behavior. For example, rural eligible nonparticipants spent significantly less on beef and veal, fish, fresh vegetables, and food away from home, but significantly more on cereal products, fats and oils, and sugar and other sweeteners than similar urban eligible nonparticipant households. Households located in the Northeast spent more on total food, food at home, bakery products, beef and veal, other red meats, poultry, fish, dairy products, and nonalcoholic beverages than similar eligible nonparticipants residing outside the Northeastern region.

The data in table 1 also suggest that race and household composition influence household food purchase behavior. White eligible nonparticipant households spent significantly less on pork, poultry, and fish, but significantly more on bakery products, dairy products, nonalcoholic beverages, miscellaneous prepared foods, and food away from home than similar black households. Households with children tended to spend less on food than households of the same size with only adults. Households with members over 65 years generally spent more on food at home and considerably less on food away from home than similar households with middle-aged adults. These

⁶ Many of these studies are summarized in (1).

Table 1—Estimated weekly per capita food expenditure equations, eligible nonparticipant households

Independent variable	Total food	Food at home	Cereal products	Bakery products	Beef and veal	Pork	Other red meats	Poultry	Fish	Eggs
	Dollars									
Intercept	8.8664 (7.74)	5.3374 (5.23)	0.3234 (4.39)	0.1858 (1.63)	0.5909 (2.61)	0.7580 (4.22)	0.3046 (3.13)	0.4145 (3.10)	0.1938 (2.43)	0.1974 (3.09)
URBN	.6354 (1.43)	.0127 (.03)	-.1137 (-3.98)	-.0290 (-.66)	.1773 (2.02)	-.0536 (-.77)	.0512 (1.35)	.0855 (1.65)	.0828 (2.67)	-.0030 (-.12)
NE	2.2486 (3.69)	1.7838 (3.29)	-.0569 (-1.45)	.2513 (4.15)	.2472 (2.05)	.0142 (.15)	.2656 (5.12)	.2280 (3.21)	.1370 (3.07)	.0119 (.35)
NC	-1.0786 (-1.93)	-.6521 (-1.31)	-.1012 (-2.82)	.0791 (1.42)	-.2117 (-1.92)	-.0154 (-.18)	.0401 (.84)	-.0274 (-.42)	-.0298 (-.77)	-.0228 (-.73)
S	-.5295 (-.99)	-.2713 (-.57)	-.0398 (-1.16)	.0445 (.84)	-.0833 (-.79)	.1091 (1.30)	-.0055 (-.12)	.1081 (1.74)	-.0435 (-1.17)	-.0061 (-.21)
WHT	.4556 (.92)	-.2206 (-.50)	-.0210 (-.66)	.1394 (2.82)	.0004 (.01)	-.4425 (-5.67)	-.0697 (-1.65)	-.3021 (-5.22)	-.1381 (-3.99)	-.0295 (-1.06)
PY	.08285 (4.47)	.06135 (3.72)	.00275 (2.31)	.00614 (3.33)	.00849 (2.32)	.00520 (1.79)	.00138 (.87)	.00248 (1.15)	.00068 (.52)	.00061 (.59)
NAG1	-3.4844 (-2.30)	-.8080 (-.60)	-.1137 (-1.17)	.1042 (.69)	-.4554 (-1.53)	-.3384 (-1.43)	-.1254 (-.98)	-.1276 (-.72)	-.0754 (-1.72)	.0468 (.55)
NAG2	-1.9375 (-1.90)	-1.2266 (-1.35)	-.0711 (-1.09)	.1041 (1.03)	-.4146 (-2.06)	-.1615 (-1.01)	-.1470 (-1.70)	-.1516 (-1.28)	.0204 (.29)	-.0244 (-.43)
NAG4	.7964 (.68)	1.5173 (1.46)	.1012 (1.35)	.1576 (1.36)	.1622 (.70)	.3395 (1.86)	.0929 (.94)	.2445 (1.80)	.0402 (.50)	.1195 (1.84)
NAG5	1.7453 (2.06)	3.8475 (5.11)	.1503 (2.76)	.3705 (4.41)	.4502 (2.69)	.4988 (3.76)	.0566 (.79)	.3228 (3.28)	.1204 (2.04)	.1971 (4.17)
NAG6	-.9454 (-1.25)	2.9135 (4.33)	.1351 (2.78)	.3529 (4.69)	.3098 (2.07)	.3081 (2.59)	.0138 (.22)	.1876 (2.13)	.1017 (1.93)	.1713 (4.06)
LNFM5	-1.3084 (-3.19)	.0729 (.20)	.0555 (2.11)	-.0236 (-.58)	.0842 (1.04)	.0902 (1.40)	.0064 (.19)	.0154 (.32)	.0150 (.53)	-.0056 (-.25)
R ²	.12	.10	.04	.08	.05	.06	.04	.06	.04	.04
S.E.E. ³	7.41	6.59	.48	.74	1.46	1.16	.63	.86	.52	.41

See footnotes at end of table.

Continued

Table 1—Estimated weekly per capita food expenditure equations, eligible nonparticipant households—Continued

Independent variable	Dairy products	Fresh fruits	Fresh vegetables	Processed fruits	Processed vegetables	Sugar and other sweeteners	Fats and oils	Non-alcoholic beverages	Miscellaneous prepared foods	Food away from home
Intercept	0.5541 (3.51)	0.2099 (2.36)	0.2214 (2.28)	0.2226 (2.95)	0.2204 (2.89)	0.2415 (2.91)	0.2202 (3.24)	0.2603 (2.31)	0.2300 (1.66)	3.5309 (6.06)
URBN	-.0035 (-.06)	.0226 (.65)	.0922 (2.45)	.0069 (.24)	.0074 (.25)	-.1152 (-3.57)	-.1254 (-4.74)	-.0323 (-.74)	-.0361 (-.67)	.6228 (2.75)
NE	.3055 (3.63)	.0282 (.59)	.0922 (1.79)	.0274 (.68)	-.0319 (-.79)	-.0349 (-.79)	-.0108 (-.30)	.1886 (3.15)	.1350 (1.83)	.4647 (1.50)
NC	-.0406 (-.53)	-.1258 (-2.89)	-.0483 (-1.02)	-.0140 (-.38)	-.0594 (-1.60)	-.0288 (-.71)	-.0450 (-1.36)	-.0024 (-.04)	.0013 (.02)	-.4268 (-1.50)
S	-.0655 (-.89)	-.1679 (-4.04)	-.0451 (-1.00)	-.0495 (-1.41)	-.0074 (-.21)	-.0708 (-1.83)	-.0256 (-.81)	.0534 (1.02)	.0253 (.39)	-.2583 (-.95)
WHT	.2419 (3.53)	.0422 (1.09)	-.0055 (-.13)	-.0286 (-.88)	-.0188 (-.57)	.0700 (1.94)	.0499 (1.69)	.1179 (2.42)	.1743 (2.91)	.6762 (2.68)
PY	.00665 (2.60)	.00267 (1.85)	.00280 (1.79)	.00351 (2.87)	.00290 (2.35)	.00010 (.07)	.00326 (2.97)	.00497 (2.73)	.00699 (3.12)	.00215 (2.28)
NAG1	-.0017 (-.01)	-.0396 (-.34)	-.1517 (-1.19)	-.1326 (-1.33)	-.0580 (-.58)	.0967 (.88)	-.0119 (-.13)	.1224 (.82)	.4570 (2.50)	-.26769 (-3.48)
NAG2	-.1746 (-1.25)	-.0786 (-.99)	-.1551 (-1.80)	-.1108 (-1.66)	-.0372 (-.55)	.0438 (.59)	-.0283 (-.47)	-.0623 (-.62)	.2221 (1.81)	-.7108 (-1.37)
NAG4	.1588 (.99)	-.0228 (-.25)	.1032 (1.05)	-.0400 (-.52)	-.0262 (-.34)	.0519 (.61)	.0220 (.32)	.1234 (1.08)	-.1098 (-.78)	-.7218 (-1.22)
NAG5	.4437 (3.81)	.2629 (4.00)	.2096 (2.93)	-.0267 (-.48)	.0580 (1.03)	.2443 (3.98)	.1920 (3.82)	.2813 (3.39)	.0235 (.23)	-.21034 (-4.89)
NAG6	.3773 (3.62)	.2447 (4.16)	.1877 (2.93)	.1027 (2.06)	.0672 (1.34)	.1719 (3.13)	.0993 (2.21)	.0972 (1.31)	-.0056 (-.06)	-.38600 (-10.04)
LNFM5	.0116 (.21)	-.0013 (-.04)	.0114 (.33)	.0243 (.90)	.0010 (.04)	-.0231 (-.77)	-.0067 (-.28)	-.0379 (-.94)	-.1022 (-2.06)	-.13820 (-6.63)
R ²	.08	.08	.06	.05	.02	.03	.05	.04	.02	.12
S.E.E. ³	1.02	.58	.63	.49	.49	.54	.44	.73	.89	3.77

¹Numbers in parentheses denote *t* values.

²Coefficient of determination.

³Standard error of regression.

results suggest that to measure the Food Stamp Program's impact on household food purchase behavior accurately requires controlling for differences in characteristics between participants and nonparticipants.

IMPACT OF THE FOOD STAMP PROGRAM ON FOOD PURCHASES

To control for differences in characteristics between participants and eligible nonparticipants, I used the estimated relationships to predict food purchases by eligible nonparticipants assuming they possess the same (average) characteristics as Food Stamp Program participants. Table 2 gives the mean values for these characteristics (independent variables). Thus, the predicted average per capita weekly total food expenditures by eligible nonparticipants possessing the same characteristics as participants are:

$$\begin{aligned} E = \$9.28 = & 8.8664 + (.6354) \\ & (.8079) + (2.2486) (.1688) \\ & - (1.0786) (.2316) - (.5295) \\ & (.4129) + (.4556) (.5943) (2) \\ & + (.0828) (24.1952) - (3.4844) \\ & (.2432) - (1.9375) (.1669) \\ & + (.7964) (.0973) + (1.7453) \\ & (.1540) - (.9454) (.1942) \\ & - (1.3084) (.9730) \end{aligned}$$

Similarly, average per capita weekly expenditures on food-away-from-home, food-at-home, and selected food-at-home categories were estimated for eligible nonparticipants possessing the same characteristics as Food Stamp Program participants. Table 3 presents these esti-

mates plus the actual food purchases by Food Stamp Program participants and eligible nonparticipants.

If we assume participants have the same purchasing patterns as similar nonparticipants, they would have spent \$9.28 per person per week on food if they had not participated in the Food Stamp Program. However, they actually spent \$10.16 per person per week on food, which implies that the per capita bonus of \$4 per week increased per capita food expenditures by 88 cents per week (9.5 percent). Per capita food-at-home expenditures were increased by an average of \$1.45 per week (19 percent), whereas per capita food-away-from-home expenditures were reduced by 57 cents per week (36 percent).

The large estimated decline in food-away-from-home purchases is surprising. Food stamps cannot be used to purchase food away from home. But by participating in the Food Stamp Program, the household can use a portion of the income formerly spent on food at home to purchase food away from

home and nonfood items. The above results suggest however, that Food Stamp Program participant households not only do not allocate any of these savings to food away from home, but that they actually reduce such expenditures. One explanation may be that low-income households view at-home and away-from-home food purchases as substitute sources of food. And since the Food Stamp Program subsidizes food-at-home purchases, thus causing an increase in such purchases, Food Stamp Program participants react by partially substituting increases in food-at-home purchases for food purchased away from home.

Participation in the Food Stamp Program increased purchases in all at-home food expenditure groups (table 3). Per capita total at-home food expenditures rose an average 19 percent. Food-at-home categories with large increases included cereal products (42 percent), processed vegetables (35 percent), pork (33 percent), nonalcoholic beverages (30 percent), eggs (23 percent), dairy products (22 percent), and poultry (22 percent).

Table 2—Mean values of independent variables for Food Stamp Program participants and eligible nonparticipants

Independent variable	Eligible nonparticipants	Participants
URBN	0.7696	0.8079
NE	.1721	.1688
NC	.2481	.2316
S	.3972	.4129
WHT	.8185	.5943
PY (dollars)	27.2338	24.1952
NAG1	.1380	.2432
NAG2	.1515	.1669
NAG4	.0793	.0973
NAG5	.1617	.1540
NAG6	.3227	.1942
LNFM5	.7797	.9730

Table 3—Estimated impact of the Food Stamp Program on per capita weekly food purchases of low-income households, 1973-74

Item	Participants (actual)	Eligible nonparticipants (actual) ¹	Impact of Food Stamp Program
	----- Dollars -----		Percent
Total food	10.16	10.14	20.88*
Food at home	9.16	8.32	1.45*
Bakery products	.69	.72	.06*
Beef and veal	1.09	1.04	.14*
Cereal products	.44	.34	.13*
Dairy products	1.23	1.14	.22*
Eggs	.32	.28	.06*
Fats and oils	.28	.28	.04*
Fish	.25	.22	.02
Fresh fruits	.31	.29	.02
Fresh vegetables	.43	.42	.06*
Miscellaneous prepared foods, condiments, and seasonings	.58	.55	.03
Nonalcoholic beverages	.69	.58	.16*
Other red meats	.38	.36	.02
Pork	1.02	.74	.25*
Poultry	.62	.48	.11*
Processed fruits	.24	.25	.03
Processed vegetables	.35	.28	.09*
Sugar and other sweeteners	.25	.27	.01
Food away from home	1.00	1.82	-.57*
		1.57	-36.3

¹ Predicted weekly per capita expenditures of eligible nonparticipant households possessing the same characteristics as Food Stamp Program participants.

² Column 1 minus column 3. A * indicates difference is significant at the 0.01-percent level of confidence. A ** indicates difference is significant at the 0.05-level of confidence.

³ Column 4 divided by column 3.

... on average, each dollar distributed through the Food Stamp Program increased food purchases by 22 cents. . . . The Food Stamp Program . . . is 2.7 times more effective in expanding household food purchases per dollar distributed than is a cash transfer program.

Food Stamp Program participation also raised household expenditures on beef and veal (15 percent), bakery products (10 percent), fats and oils (17 percent), and fresh vegetables (16 percent). Participation did not, however, expand household expenditures on fish, fresh and processed fruits, sugar and other sweeteners, and miscellaneous prepared foods significantly.

The increase in food purchases per dollar distributed is a measure of the Food Stamp Program's effectiveness. For total food, the estimated effectiveness is 88 cents divided by \$4 (the average bonus received per capita) or 22 cents (table 4). Thus, on average, each dollar distributed through the Food Stamp Program increased food purchases by 22 cents. In comparison, the coefficients of per capita income (PY) in table 2 indicate that a dollar of additional income would increase participants' food purchases 8 cents. The Food Stamp Program, therefore, is 2.7 times more effective in expanding household food purchases per dollar distributed than is a cash transfer program. This finding agrees with those of other studies (2, 5).

Total at-home food purchases were increased by 36 cents, whereas away-from-home food purchases were reduced by 14 cents—for each dollar distributed through the Food Stamp Program. In comparison, a cash transfer would expand at-home food purchases by 6 cents and away-from-home food purchases by about 2 cents per dollar distributed. Compared with a cash transfer program, the pre-1979 Food Stamp Program seemed to be

substantially more effective in expanding household purchases of food.⁷

IMPLICATIONS

The Food Stamp Program has undergone major change since 1972-74, the study period. The elimination of the purchase requirement on January 1, 1979, likely reduced the program's effectiveness as it enables participants to spend money previously used to purchase

⁷ Related reports the reader may find useful are summarized in (4).

food coupons on items other than food as well as food. Also, because food coupons had to be used to purchase food for consumption at home, elimination of the purchase requirement permits food stamp households to allocate more of their income to food away from home. The results presented likely overstate the increase in food-at-home and the decline in food-away-from-home expenditures resulting from participation in the current Food Stamp Program. However, the current Food Stamp Program is at least as effective as cash transfers in

Table 4—Impact of \$100 distributed through the Food Stamp Program and a cash transfer program

Item	Food Stamp Program	Cash transfer program ¹	Relative difference ²
	----- Dollars -----	Percent	
Total food	22.00	8.28	2.7
Food at home	36.25	6.13	5.9
Bakery products	1.50	.61	2.5
Beef and veal	3.50	.85	4.1
Cereal products	3.25	.28	11.6
Dairy products	5.50	.66	8.3
Eggs	1.50	.06	25.0
Fats and oils	1.00	.33	3.3
Fish	.50	.07	7.1
Fresh fruits	.50	.27	1.9
Fresh vegetables	1.50	.28	5.4
Miscellaneous prepared foods, condiments, and seasonings	.75	.70	1.1
Nonalcoholic beverages	4.00	.50	8.0
Other red meats	.50	.14	3.6
Pork	6.25	.52	12.0
Poultry	2.75	.25	11.0
Processed fruits	.75	.35	2.1
Processed vegetables	2.25	.29	7.8
Sugar and other sweeteners	.25	.01	25.0
Food away from home	-14.25	2.15	—

— = Not applicable.

¹ Estimated impact of an additional \$100 of income on food purchases by low-income households. The coefficient of PY in table 3 multiplied by 100.

² Column 1 divided by column 2.

expanding participants' food purchases. The results provide both maximum and minimum estimates of the current program's effectiveness. Each dollar distributed through the current Food Stamp Program increases total food expenditures at least as much as a dollar of added income would increase it (8.3 cents) but less than a dollar's worth of added food stamps would increase it (22 cents).

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RESEARCH REVIEW

CHRONIC INFLATION AND THE GNP

By Alan R. Bird*

Inflation and recession have long been considered mutually exclusive. However, I suggest that chronic inflation, the increasingly important condition of the seventies and the eighties, is not the opposite of chronic recession. The failure to recognize this difference between chronic and cyclical inflation and the associated efforts to "cure" inflation by traditional means intensify chronic inflation.

Chronic inflation occurs when large, widespread, uneven, and frequent price increases persist to the extent that they are generally expected to continue. They persist because of structural changes and attitudes beyond changes in the money supply, although the money supply itself becomes increasingly opened up as more goods function as, and increasingly substitute for, traditional money as a store of value.

Structural changes and attitudes undermine incentives for increased resource use and resource productivity to the point of precipitating chronic recession. A notable structural change is the reduced mobility of skilled, experienced, and potentially the most innovative members of the labor force due to vested interests in pension plans and other perquisites specific to their respective employers, public or private. This can reduce the incentive to increase productivity; salary scales are compressed for this group. Featherbedding can exacerbate this problem. Businesses tend to

invest in appreciating items, such as real estate and inventories, at the expense of buying new equipment.

In turn, chronic recession interacts with chronic inflation so that they occur jointly. This explains the irony of attempting to cure chronic inflation with recession.

Chronic inflation and chronic recession must be curbed together. The role of the money supply alone becomes increasingly complex. When inflation and recession co-exist, is it more important to increase or decrease the money supply or keep it the same? Structural, attitudinal, and institutional changes have an intuitively larger role. So does information on these changes and their effects on inflation.

Price indices, such as those for consumer and producer prices, have come under attack as untrustworthy measures of inflation. A slower increase in the Consumer Price Index is unlikely to indicate success in curbing chronic inflation, unless this change is accompanied by other changes that show increased resource productivity and resource use, including increased labor utilization. These changes, in turn, should lead to an increased rate of real national economic growth. Thus, a reliable measure of national economic growth is crucial to an adequate monitoring and understanding of inflation. Yet our acceptance of the Gross National Product (GNP) as the prime indicator of national economic growth, even after the onset of chronic inflation, may be a crucial impediment to our understanding of chronic inflation and interrelated chronic recession.

The standard national statistics show an average annual gain in current GNP of about 9.74 percent, from \$935.5 billion in 1969 to \$2,368.8 billion in 1979. The correction to 1972 prices shows a much smaller, but impressive, average annual gain of about 2.87 percent from \$1,078.8 billion in 1969 to \$1,431.6 billion in 1979. This implies an annual inflation rate of 6.87 percent that, I suggest, includes the chronic component that might be called the "core" rate.

As population growth has slowed, converting real GNP to real GNP per capita would increase the estimated real growth rate, although there are offsetting considerations, such as the uncounted illegal immigrants. Yet per capita real GNP overestimates U.S. economic progress in the seventies and thus works against solving the problem of chronic inflation.

Current GNP is, of course, the sum of the quantities of all final goods and services for the latest year times their respective current prices. GNP in 1972 dollars (real GNP) is the sum of the quantities of all new goods and services for each year times their respective 1972 prices.

I suggest that events during the last decade underscore the well-recognized need to revise the real GNP to account for major changes in the quality of goods and services that are not reflected in price changes. Under changes in quality, I include traditional changes such as those that affect the durability of an article. I also include the remaining changes in social and economic conditions that have accompanied chronic inflation and could be expected to change people's per-

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ceptions of their levels of living. The former changes are, more or less, included in routine updates of GNP estimation procedures, although periods of gross change are less easily assimilated this way. The latter changes, the ones I contend have been dominant in the last decade, have not been accounted for, as such an accounting would require basic changes in the conventions associated with the calculation of the GNP.

These events also call for two further revisions in real GNP. These revisions would account for (1) inflation-induced changes between prices of currently purchased goods and services and those purchased previously and (2) inflation-induced changes between prices of goods and services counted in the GNP and other goods and services, such as land, that are traded in commercial markets but not counted in the GNP. The result would be a conceptual "true real GNP" that, I suggest, would graph as a horizontal, or even a declining, curve over the last decade.

Social change in the seventies was sufficient to mislead those who compare Consumer Price Index values in 1979 with those in 1969. Fifty-five percent of eligible adult women are now in the labor force, compared with 40 percent in 1970 and 35 percent in 1960. This change may partially reflect efforts by families to maintain their level of living in the face of increased inflation. From 1970 to 1979, the ratio of all those currently divorced to those currently married doubled, from 47 to 92 per 1,000 persons; and the percentage of children under 18 living with one parent rose from 12 to 19. These

changes suggest a major increase in the quantity of services traded in commercial markets, formerly provided within families or volunteered to society with no charge recorded in the public accounts, along with a likely increased demand for new services such as TV dinners.

The average quality of some consumer goods and services may have declined. For example, even after we allow for increases in oil prices, consumers are paying for an inferior petroleum product, compared with a decade ago. There are fewer choices. Some octane levels and kinds of gas are not generally and consistently available. Many stations provide no regular maintenance or repair, not even the change or repair of a flat tire. Some even charge for "air." "Self-service" is more common, but with a negligible price differential. Other examples of quality decline come readily enough to mind. Quality is increasing in some goods and services, but these improvements are increasingly offset by declines in other goods and services.

The recent low level of business fixed investment is a factor in our resource productivity slowdown. However, parallel changes in the quality of investment have occurred. Two examples are "the apparent malnutrition of our research and development effort" and "the effects of escalating government regulation."¹ The latter are thought to dilute further the amount of investment directed toward increased production of goods and services for commercial markets. Offsetting social benefits do not necessarily result in increased net total benefits to soci-

ety. Chronic inflation itself can compound this quality decline by discouraging needed long-term investment and diverting funds toward asset appreciation.

Residential housing is another significant component of investment that is subject to quality changes. As buying a house for cash is not generally an option, comparisons of true housing prices must include increased financing costs associated with increased inflation. Moreover, mortgages are generally less assumable. The quality of work and materials, and associated maintenance costs, while not easily measured, are potentially significant inflationary factors. Bussing; increased energy costs; increased hazards from energy and chemicals; and the changing age structure of the population and associated school openings, closings, and consolidations have affected the average quality of new housing, particularly by distorting locational advantages, in ways unique to the seventies and eighties. Changes in market prices do not necessarily reflect these major changes in life style, especially as earlier choices are no longer available.

Government purchases of goods and services are valued conventionally at "cost," and this cost makes no allowance for quality changes. It is not discounted for deficit spending, although this spending has probably added to inflation or lowered the capital

¹ Burton G. Malkiel, "Productivity—The Problem Behind the Headlines," *Harvard Business Review*, May-June 1979, p. 82.

intensity of production or both.² The switch to a volunteer military force, for example, has evoked widespread concern about defense preparedness. Does each dollar of military expenditure buy what a comparable dollar would have bought in the days of the draft? The administrative costs of safety and environmental regulations need to be deflated in line with any net reduction in productivity that they cause. Conventional real spending on education and training has increased greatly, yet the quality of these services is questioned.

Chronic inflation creates two further needs to qualify the price component of real GNP. Under conventional procedures, current GNP is corrected to real GNP by pricing current quantities of final goods and services at some historic or base price. However, chronic inflation itself tends to cause final goods and services to appreciate. A new durable good bought in 1972 would not depreciate so rapidly as without chronic inflation. Alternatively, if a new 1972 good were available in 1979, it would sell for more than the 1972 price adjusted up to the 1979 price level. Because of chronic inflation, the 1972 new good was actually underpriced in 1972 for consumption in 1979. Thus, the updated 1972 price should be higher than shown by the base.

Another convention associated with calculating the GNP distorts the results in a time of chronic inflation. Land and other natural

resources, works of art, and other collectibles are not currently included in this calculation nor were they in the past. Yet, the more intense the chronic inflation, and the more it is expected to continue, the higher the value of these assets relative to goods and services counted in the GNP. Although these assets are not counted directly, they are traded in commercial markets in competition with goods and services that are counted. In fact, increased demand for such assets is a feature of chronic inflation. The prices of items counted in the GNP relative to asset values are, therefore, diminished by this progressive increase in asset values. Yet, the prices of new goods counted in the GNP in years subsequent to the base year (1972) are not corrected for this asset appreciation in successive years. The more inflation persists and intensifies, the greater would be the correction for this price change, and the more the curve showing real GNP would tend to flatten or decline over time. The most significant asset appreciation for the average worker is that of his or her home. To realize on this asset, however, he or she would need to sell that home or borrow on it more heavily, actions that would tend to increase the money supply. The businessman or woman would have more incentive to buy assets as an inflation hedge than to buy plant and equipment that enhance labor productivity. And these activities would likely fuel further inflation.

To summarize, conventional accounting and estimation procedures used to derive real GNP probably result in a measure that progressively diverges from the real level

of living of most families under chronic inflation. This divergence may be large enough that correcting for it would reveal a real level of living over the last decade that has stagnated or declined and would thereby define a chronic recession paralleling chronic inflation. Increased, chronic underutilization of labor is thus an expected feature of chronic inflation; as are reduced incentives and productivity for skilled, experienced, and potentially the most innovative members of the labor force. Underemployment of the labor force and underutilization of national resources can thus be expected to intensify as chronic inflation continues, although the associated changes in unemployment rates may be more erratic due to the likely limited reliability of the unemployment rate as a measure of labor utilization. Incentives for increased productivity-oriented investment, compared with appreciation investment, may likewise be dampened. The coexistence of progressively more intense chronic inflation and recession suggests that changing the money supply, even to the point of worsening a recession, will never alone curb chronic inflation and may worsen it. Parallel efforts to increase work incentives, enhance resource productivity, increase the average quality of output, and increase the utilization of all national resources, including labor and management, have an implied larger role in curbing chronic inflation. The success of these efforts would depend on accommodating to major social and institutional changes, some of which may now be reinforcing chronic inflation.

² Martin Feldstein, "Fiscal Policies, Inflation, and Capital Formation," *American Economic Review*, Vol. 70, No. 4, Sept. 1980, p. 647.

MERGING RESOURCE DATA FROM DISPARATE SOURCES

By Linda L. Hagen and Paul T. Dyke*

Environmental cost-benefit issues have been gaining importance in congressional legislation and in public opinion. In response, complex interdisciplinary modeling efforts have evolved. These models may be multiobjective and multi-resource in scope. They require comprehensive data bases. For example, determination of crop yields depends on soil characteristics, climatological factors, water balance characteristics, irrigation and management practices, available nutrients, and other physical factors. To place a value on those yields, analysts need economic data on costs of production and crop prices. Soil erosion changes the physical characteristics of the soil. It also changes the costs of production as conservation practices are adopted, and use of inputs, such as fertilizer, increases. Therefore, a complete study of the effects of soil erosion on crop yields, and their costs, would require both physical and economic data bases.

Analysts of national environmental and natural resources policy require detailed cross-sectional data that are nationally consistent. Massive amounts of data are available from various data collection efforts. However, surveys are often designed for specific purposes, which limits use of the resultant data. Two types of survey inadequacies are common:

- (1) Economic (physical) surveys do not contain physical (economic) data or locational codes matchable with existing physical (economic) data.

- (2) Economic (physical) surveys containing physical (economic) data may not use geographic boundaries, units of measure, or locational codes consistent with existing physical (economic) data bases.

Additional surveys to collect the information needed would be costly and time-consuming. Furthermore, policy questions often require immediate responses. Given these time and budget constraints, creating a synthetic data file is sometimes the only feasible alternative. A synthetic file is one created "by merging two or more existing ones [files] that, between them, contain the needed information" (12)¹. This is accomplished by matching selected codes or characteristics in existing data files. The synthetic resource economic data file is one procedure that can be utilized as a partial substitute for a comprehensive data base.

USDA personnel created a resource economic data file by matching and merging data from six disparate sources. Here we discuss the steps by which the new data base was generated.

BACKGROUND

The Soil and Water Resources Conservation Act of 1977 (RCA) was a congressional mandate to USDA calling for evaluation of USDA soil and water conservation programs. As part of the RCA appraisal effort, we developed a

yield/soil loss simulator (4, 7, 8, 9, 18). Earlier studies of erosion effects had been performed for specific sites or river basins. Estimation techniques varied widely; thus, results are not easily compared. Furthermore, these diverse results could not be aggregated for use at the national level. Our analysis was the first attempt to evaluate the effects of soil erosion by use of a nationally consistent data base and model. The simulator was incorporated into the structure of the National Agricultural Linear Programming Model located at Iowa State University (11, 18).

To isolate the effects of erosion on productivity, we modeled yield as a function of soil characteristics. Although the yield model was relatively simple, its data requirements were not. The required data were located in six files. Creation of the merged data base (see figure) involved the first application of the concepts utilized in the Land and Water Resources and Economic Modeling System (LAWREMS). LAWREMS is an information system of computerized data and models which was designed to promote use of data from disparate existing sources (3, 10, 13).

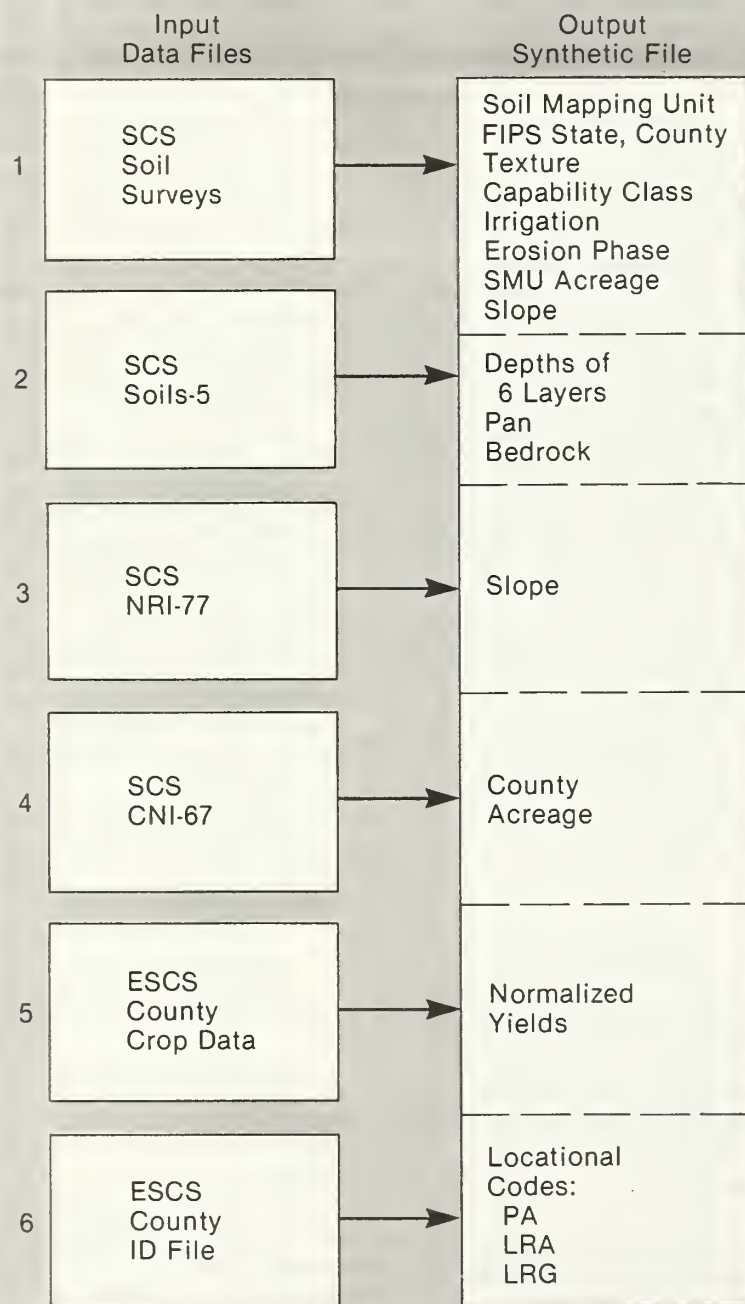
THE PHYSICAL DATA: SOIL CHARACTERISTICS

The Soil Conservation Service (SCS) *Soil Surveys* (19) identify and classify the soil series in a county and describe the soil's characteristics, formation, and morphology. They provide information on capability groups, suitability ratings, and management needs of soils by land use, such as cropland, range,

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¹ Italicized numbers in parentheses refer to items in References at the end of this article.

Steps to Development of Merged Data File



woodland, and wildlife habitat.

County soil maps (contained in the survey publication) define soil mapping units (SMU)². The SMU was the observation unit used in our

The *Soil Surveys* are widely used in county and project level development planning. However, use of these data in research has been limited because they were not computerized. Personnel in the Natural Resource Economics Division, ESCS, have automated selected soils data from the published county surveys (6). From this file we obtained the following data by soil mapping unit: slope, texture, land capability class/subclass, erosion phase, acreage, irrigation practice, and Federal Information Processing Standards (FIPS) State and county codes.

Another SCS data base, the Soils-5 Soil Survey Interpretations file (20), is computerized but difficult to use. The file contains over 12,000 records of unique soil series. Each record is approximately 8,000 characters long and is interlaced with codes used to select characteristics relating to different phases of the soil series. Soil depths of up to six layers and depths to bedrock were obtained from Soils-5, then matched and merged to *Soil Survey* data by soil mapping unit.

As previously mentioned, slope data were obtained from the *Soil Surveys*. However, in some cases, the slopes were reported descriptively, not numerically. Examples include "steep," "hilly," and "undulating." These slopes would be considered as missing values by

² See Glossary at the end of this article.

the computer model which would effectively lower the average slope in precisely those regions with the steepest slopes. Therefore, we obtained numerical slope values from the 1977 SCS National Resource Inventory (NRI) (17) to replace descriptive slope terms.

THE ECONOMIC DATA: NORMALIZED YIELDS

Approximately 1,100 county Soil Surveys were available at the time of the study. These were published between 1958 and 1978. Yields reported in the survey data reflect random time and technology factors, depending on when during the 20-year period the county was surveyed. Thus, the *Soil Survey* yields were normalized to bring all reported yields to a common base year—1974.

The first step in the normalization process was estimating 1974 normal yields at the county level. These were calculated with linear regression time-trend analysis from published ESCS County Historical Crop Data for 1969-76 (5). These 1974 normal yields by crop and county were used as targets in the next step of the normalization procedure, the calculation of 1974 normal yields for each SMU within the county. Two sets of acreage were used in the weighting process. The *Soil Survey* was the source for the total acreage in each SMU. Second, estimated acreages by SMU for each crop were derived from the SCS 1967 Conservation Needs Inventory (CNI) (16). The CNI was used because it is the only source of

county-reliable data that contains capability class/subclass information by major crop groups. The resulting normalized yields by SMU were merged into the original soil survey data file.

A USEFUL LINK: COUNTY ID FILE

Observations in the yield/soil loss analysis were SMU's. Final results were calculated for Producing Areas (PA), the geographic level used by the National Linear Programming Model. The 105 PA's, which were defined by the Water Resources Council for use in the first National Water Assessment (11), overlap States but follow county boundaries.

The ESCS County Identification and Cross-Reference Data File (County ID) (1, 2) contains many locational codes including: Water Resource Sub-Area (WRSA), Land Resource Region (LRR), Aggregated Sub-Areas (ASA), Firm Enterprise Data System code (FEDS), Standard Metropolitan Statistical Area (SMSA), CNI State and county, National Science Foundation market regions, National Oceanic and Atmospheric Administration State and division, and latitude and longitude. The file is useful in linking data bases.

The County ID file was the source for PA, Land Resource Area, and Land Resource Group codes. We merged these into our synthetic file by matching State and county FIPS codes. The final resource economic data base contained approximately 240,000 observations by

SMU, ranging from 9,000 to 50,000 observations per crop.

CONCLUSIONS

Although economic and physical data are rarely collected simultaneously, nationally consistent resource economic data files are increasingly needed for interdisciplinary models that can be used in natural resource policy and environmental cost-benefit analyses. An interdisciplinary approach to data collection is recommended to solve the data problem.

Creating synthetic files from existing sources has its limitations. It can be very expensive in terms of labor and computer costs. Loss of observations due to match failures can be a serious problem. Some files simply cannot be matched with one another because no common characteristic exists between them. In some cases, therefore, data collection is necessary, but a new approach is needed.

Sample surveys should be designed with multiple objectives in mind. That is, an interdisciplinary approach is needed when data are collected. A test case in Missouri provides a good example. It involved cooperation between SCS soil scientists and personnel in ESCS Statistics in collecting the Objective Yield Survey. A soil classification and analysis were performed according to soil survey procedures for each sample point in the Yield Survey. This type of coordinated data collection activity needs to be done on a national scale to provide good resource economic data for use in national policy analyses.

GLOSSARY

Soil profile	The sequence of natural layers, or horizons, in a soil. It extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.
Soil series	Soils having profiles that are almost alike. Except for different textures in the surface layer, all soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics.
Soil phases	Series are divided into phases on the basis of differences in texture of surface layer, and in slope, stoniness, or some other characteristic that affects use of the soil. The name of a soil phase indicates a feature that affects management of the soil.
Soil mapping units	The areas shown on a soil map. On most maps detailed enough for use in planning, a mapping unit is nearly equivalent to a soil phase. The mapping unit will indicate the dominant soil phase, although other phases may be present.
Land capability class/subclass	Soil classification scheme. Numerals I-VIII indicate progressively greater limitations and narrower choices for practical use. Subclass

indicates kind of limitation or main risk:

e-erosion; w-wetness; s-stony; d-droughty; c-climatic factors.

Erosion phase
Classified as slightly eroded if 0-25 percent of topsoil is eroded; moderately eroded if 25-75 percent of topsoil is eroded; severely eroded if 75-100 percent of topsoil is eroded.

Source: (15).

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PRICE AND EXCHANGE RATE TRANSMISSION

By H. Christine Collins*

World prices for major agricultural commodities rose dramatically in the early seventies. The effect of international price changes on internal farm prices is interesting from a theoretical as well as a policy standpoint. This article shows which countries responded internally to international price hikes, as measured by U.S. gulf port prices, and which ones did not. The elasticity of price transmission and the elasticity of exchange rate transmission are the respective responses of a given country's prices to changes in the world price and the country's currency-dollar exchange rate, after transportation costs are taken into consideration. The elasticities are used as a bridge between the world price and a country's internal price. The principal findings in this article are:

- Most countries have experienced rising farm prices for wheat, corn, and soybeans, particularly in the seventies. Internal commodity prices rose in proportion to international trade prices in most major exporting countries, as expected under free trade. Elasticities of internal price with respect to world price under free trade equal 1.0. However, for importing countries and for countries

not heavily involved in world trade, most elasticities were significantly less than 1.0, which implies some internal protection from world price changes.

- For wheat, Canada and Uruguay exhibit nearly perfect price and exchange rate transmission. Argentina, Australia, and Turkey transmit price, but not exchange rates. Argentina had a multiple exchange rate system to prevent exchange rate transmission for wheat. The major wheat exporters, except France (which showed virtually no price transmission), had nearly perfect price transmission.
- Brazil, Thailand, Canada, Chile, Turkey, and Tanzania are the only corn-producing countries whose price and exchange rate transmission elasticities are close to 1.0 and, therefore, whose farm prices are closely related to the world market price. Argentina, Pakistan, Zaire, and Morocco have nearly perfect price transmission, but exchange rate changes have not been transmitted to the farm level. Argentina also has a multiple exchange rate scheme for corn. The above two groups include all the world's major corn exporters, except South Africa. South Africa shows imperfect price transmission and virtually no exchange rate transmission.
- Brazil, Paraguay, and Canada are the only soybean-producing countries with approximately perfect exchange rate and price transmission. Brazil is the principal U.S. competitor on the international soybean market. Japan appears to show price transmission. This is contrary to what would be expected as Japan has an extremely high support price for soybeans.
- Most other countries have some form of price protection for their wheat, corn, and soybean producers. The European Community's Common Agricultural Policy for grains is the most significant. The Mexican Government subsidizes its flour mills and feed compounders to offset high producer prices. The Indian Government is the largest single buyer of grain and it guarantees a set price to the producer. The Brazilian Government sets the farm price for wheat at a high level. Mexican, Indian, and Brazilian farm prices are keyed from the U.S. gulf ports price, whereas the European Community's internal farm prices are generally not.
- Some countries, like Yugoslavia, appear to set their internal farm prices with the gulf ports price, but 1 year later.
- From 1966 through 1974, the exchange rate of eight countries changed more than 100 percent in relation to the U.S. dollar. However, this change was not necessarily transmitted through internal

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farm prices of the major commodities. Brazil, Chile, Colombia, Israel, and Korea permitted full transmission of the exchange rate influence to the farm price, but Argentina, Pakistan, and Zaire only partially did so. Because of varying government policies toward exchange rates and farm prices, transmission of the exchange rate to farm prices was virtually zero to, for example, West Germany, but about 1 to the Philippines, Korea, and Japan.

Price and exchange rate transmission elasticities for corn demonstrate that transmission can run the full range from zero to 1. Of the 33 corn-producing countries, 8 have price transmission elasticities not significantly different from 1; 5 have price transmission elasticities not significantly different from zero. Yet a third category of countries falls between the extremes, which means internal producer prices are only partially insulated from world market prices. Ten countries, including Brazil, Chile, and Colombia, had full exchange rate transmission from the world market to the farm. However, 12 countries had no exchange rate transmission for corn, and 4 countries were between zero and 1.

COMPARISON WITH OTHER STUDIES

Bredahl, Meyers, and Collins set the price transmission elasticity at either zero or 1 (4).¹ However, this

¹ Italicized numbers in parentheses refer to items in the References at the end of this article.

study shows instead that elasticities range from zero to 1. A price transmission elasticity of 1 may be termed a perfect price transmission. Where governments insulate internal producer prices from world market prices (with variable import levies, subsidies, or quotas), the price transmission elasticity will be at or near zero. Whereas Bredahl, Meyers, and Collins used a price transmission elasticity for corn of zero for the European Community, the elasticities calculated in this study range from 0.043 in West Germany to 0.674 in Italy. For Argentina, Bredahl, Meyers, and Collins set the elasticity at zero, but results of this study indicate an elasticity of 1.115 (not significantly different from 1.0). For South Africa, they assumed an elasticity of zero; calculations of this study show 0.426. Thailand and Brazil have price transmission elasticities of 0.999 and 1.101 (not significantly different from 1), respectively, in this study, rather than the zero which they assumed.

Bredahl, Meyers, and Collins pointed out that a "key question that must be resolved in evaluating the elasticity of export demand is the size of the adjustment of foreign internal prices to U.S. prices . . .," that is, price transmission (4). They referred to the models for the elasticity of foreign demand set forth by Tweeten (16) and Johnson (13). Tweeten's model is an excess demand model. The elasticity of price transmission (*Epi*), the response of a given country's price to changes in the world price, is included in Tweeten's formulation as a bridge between the world price and a country's internal

price. Johnson uses a similar relationship. However, Johnson states, "*Epi* is set equal to 1.0 and can be ignored." Bredahl, Meyers, and Collins conclude that Johnson's assumption of perfect price transmission is a convenient simplification, but it has a profound impact on the calculated elasticities and raises serious questions about their applicability. The same *Epi* should be expected between the internal farm prices of an exporting country and the gulf ports price as exporting countries compete in the same international markets. Although Bredahl, Meyers, and Collins appear to relate price transmission to demand, they include price transmission between the gulf ports and farms in major exporting countries in their example. This article employs the Food and Agriculture Organization (FAO) data base (9) of internal farm prices for wheat, corn, and soybeans in selected countries (6). The U.S. gulf ports price for these commodities is used as a measure of world price (17). The FAO data base offers the most comprehensive and consistent coverage of farm-level prices.

Although the FAO data base covers the 1966-74 period for most countries, it can sometimes be supplemented by earlier FAO price data published as *Agricultural Prices 1961-70* or by data published in agricultural yearbooks in some countries. The major weakness of the FAO data base is its short price series for many countries, from 9 to 15 observations.

Price transmission has been complicated by the shift in exchange rates for many countries relative to the U.S. dollar. The

exchange rates of Colombia, Korea, Pakistan, Israel, Yugoslavia, Zaire, the Philippines, Argentina, Bolivia, Chile, Costa Rica, and Brazil shifted so drastically that one must convert their internal prices to a common currency to unmask the existing price relationships.

Argentina and Brazil's official exchange rates increased 13 and 11 times, respectively during the 1966-75 and 1963-73 periods. Colombia and Korea (1963-74) and Zaire (1966-75) had exchange rates that tripled. However, the exchange rates of many countries, including Mexico, did not change relative to the U.S. dollar (table 1).

If there is perfect transmission of the exchange rate, the transmission elasticity of a foreign internal price relative to the foreign currency/U.S. dollar exchange rate equals 1.

EMPIRICAL MODEL

To test the relationship between the U.S. gulf ports price and domes-

tic producer price for corn, wheat, and soybeans, I estimated the price transmission and exchange rate transmission elasticities from the following model:

$$\log P = A + B_1 \log (P_{GP}) + B_2 \log (EXR)$$

where P is the internal farm price of the commodity considered and is expressed in the currency of a specific country, P_{GP} is the U.S. gulf ports price for the commodity, and EXR is the exchange rate between the U.S. dollar and the country's currency. This model assumes a constant percentage margin between the U.S. gulf ports price and the country's internal price.

This model was tested with assumptions that (1) internal farm prices changed in the same year as the U.S. gulf ports price and (2) internal farm prices changed a year later. Lagged price variables were chosen when they provided a better statistical fit than the unlagged

price variables. Several other linear and log models were fitted to this data but they are not discussed here (6).

The resulting coefficients on the exchange rate and the gulf ports price were tested to determine if they were significantly different from zero or 1. Where the exchange rate had not changed during the years under study, the coefficient b_2 was set equal to zero.

CONCLUSIONS

Price and exchange rate transmission elasticities can range anywhere between zero and 1. It can be misleading in policy models to assume *a priori* that real elasticities are exactly zero or 1. Table 2 summarizes the results of the regression analysis. Commodity-specific conclusions appeared in the introduction as highlights. More general conclusions are given. Subsequent ESCS research on wheat and corn prices supports the estimates presented here and substantiates the

Table 1—Changes in currency/U.S. dollar exchange rate, 1966-74

100 percent or more	20-100 percent	10-20 percent	1-10 percent	No change
Argentina Brazil Chile Colombia Israel Korea Pakistan Zaire	Austria Belgium Bolivia Germany, Federal Republic India Indonesia Ireland Japan Korea Malaysian Peninsula Netherlands Philippines Sweden Turkey West Germany Yugoslavia	Algeria Australia Congo Denmark Egypt Malawi Morocco Portugal Uruguay	France Italy New Zealand Nigeria South Africa Spain Thailand Venezuela Zambia	El Salvador Guatemala Kenya Mexico Paraguay Tanzania

Table 2—Calculated price and exchange rate transmission elasticities for wheat, corn, and soybeans

Country	Wheat		Corn		Soybeans	
	Price transmission elasticity	Exchange rate transmission elasticity	Price transmission elasticity	Exchange rate transmission elasticity	Price transmission elasticity	Exchange rate transmission elasticity
Algeria	0.166	0.183	—	—	—	—
Argentina	1.014(X)	.361	1.115(X)	0.453	0.429*	0.491
Australia	.707(X)	.376	—	—	—	—
Austria	.158	.196	—	—	—	—
Belgium	.068	.366	—	—	—	—
Bolivia	—	—	.250	.238*	—	—
Brazil	.199	.932(X)	1.101(X)	.782(X)	1.105(X)	.734(X)
Canada	1.086(X)	1	1.038(X)	1	.921(X)	1
Chile	—	—	.594(X)	1.001(X)	—	—
Colombia	—	—	—	—	.380	1.077(X)
Congo	—	—	.526	.681(X)	—	—
Denmark	.088*	1.330(X)	—	—	—	—
Egypt	.262	.724	.513	.055*	—	—
France	.166	.011	.481	.522*	—	—
Germany, Federal Republic	.140*	.265	.043*	.302*	—	—
Greece	.516	1	.589	1	—	—
Guatemala	—	—	.469	1	—	—
India	.774	1.915(X)	—	—	—	—
Indonesia	—	—	.486	.819(X)	.675	.568
Ireland	.511	1.262(X)	—	—	—	—
Israel	.686	1.119(X)	—	—	—	—
Italy	.484	1.638(X)	.674	1.255(X)	—	—
Japan	.262	.776(X)	—	—	.885(X)	1.484(X)
Kenya	.614	1	.447	1	—	—
Korea	.615	1.348(X)	—	—	.363	1.410(X)
Malaysian Pensinsula	—	—	.290*	1.031*	—	—
Malawi	—	—	.339*	1.121*	—	—
Mexico	.541	1	.455	1	.753	1
Morocco	—	—	1.272(X)	2.802(X)	—	—
Netherlands	.108	.722(X)	—	—	—	—
New Zealand	.398*	.199*	.678*	.279*	—	—
Nigeria	—	—	.531*	.995*	—	—
Pakistan	—	—	.981(X)	.729	—	—
Philippines	—	—	.623	.988(X)	—	—
Portugal	.218	.382	.687	.547*	—	—
Spain	.622	1.100(X)	.715	1.206(X)	—	—
South Africa	.309	.623	.426	.054*	—	—
Sweden	.268	.447*	—	—	—	—
Tanzania	—	—	1.020(X)	1	—	—
Thailand	—	—	.999(X)	1	.572	1
Turkey	.865(X)	.563	.861(X)	.283*	—	—
United Kingdom	.673	1.332(X)	—	—	—	—
Uruguay	1.349(X)	.955(X)	.470	1.102(X)	—	—
Venezuela	—	—	.661	.303*	—	—
Yugoslavia	.426	1.382(X)	.804	.990(X)	.538	1.024(X)
Zaire	—	—	.896(X)	.459	—	—
Zambia	—	—	.413	.441	—	—

*Not significant at the 95-percent level of confidence.

¹No change in exchange rates.

(X) Indicates that coefficient is not significantly different from 1, for perfect price transmission.

— = Less than 1.0 million tons per year for wheat or corn; less than 0.25 million tons per year for soybeans.

price relationships based on FAO data. The Commission of the European Community's July 1979 special publication, *Agricultural Markets, Prices Received by Farmers, Unit Values*, provides prices through the 1977/78 crop year. Greece, France, Norway, Denmark, Ireland, and Italy have farm-level wheat prices for the crop years 1966/67-1977/78 that move with the U.S. gulf ports price, when measured by the coefficient of determination. The Netherlands, Ireland, Italy, the United Kingdom, and Greece have exchange rate changes with a statistically significant impact on internal farm prices. However, none of these countries has perfect price and exchange rate transmission.

The basic transmission relationship also holds for corn, despite differences in data sources and updated time periods. ESCS regression analyses of alternative data sources (1, 2, 3, 4, 5, 7, 8, 10, 15) yield approximately the same results as the FAO price series.

When exchange rates change abruptly from an historically stable level, the model on page 10 seems to attribute a transmission elasticity greater than 1 to the exchange rate. This abrupt change may be caused by a "shock" effect on prices resulting from the sudden exchange rate change. Or, when only small changes in exchange rates occur, the equation may attribute too much, including other statistical errors, to the exchange rate variable, or statistical aberrations may occur. The data might be faulty or the exchange rate data might not line up with the price data in the respective time series.

This latter condition is a problem especially when a massive inflation and sharp changes in exchange rates have occurred. Price policy during the years being studied may have changed and the coefficients may not be able to reflect such a change.

This note is concerned with empirical estimates of the elasticity of transmission of price and exchange rates. The results indicate that models which assume *a priori* elasticities of zero or 1 are likely to be in error. I do not examine how such information should be incorporated into trade models. For example, some models might use direct estimates, as was discussed, while other models might explain transmission with intervening variables and explicit policy instruments.

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CONSENSUS AND CONFLICT IN U.S. AGRICULTURE:

PERSPECTIVES FROM THE NATIONAL FARM SUMMIT

Bruce L. Gardner and James W. Richardson, editors,
Texas A & M University Press, College Station, 1979,
280 pp. \$17.00 (cloth), \$7.95 (paper).

*Reviewed by Milton Ericksen**

In a sense this book is an anti-climax to the processes out of which it emerged. The sharpness of the debates within the task forces charged with preparing reports and the confrontation atmosphere at the summit where these reports were delivered are not captured in the book. An expansion of knowledge and a challenge to opinion had to occur among the 76 task force participants and the over 700 summit attendees. That group forms a nucleus of people from wide-ranging backgrounds and disciplines who have had face-to-face experience in discussing, learning about, and disagreeing over food and agricultural issues.

As one who belonged to a task force, attended the summit, and read the book, I was not surprised that the debate leaned more towards conflict than toward consensus. If the task force-summit process is to achieve consensus, several more summits and several more books will be required. For this first round, the participants reacted instinctively to defend their interests, ideologies, and positions.

The chapters in the book are definitely influenced by the task force chairmen. This might be expected as they had the task of giving cohesion and consistency to the subject area assigned to the task force. The reader does not get a comprehensive view of the perspectives of individual task force members.

Chapter 1, "Resource Allocation and Production Costs," states that the viewpoint of farmers

distinctly differs from those of consumers, representatives of agribusiness, government officials, and others with an interest in agriculture. Most of the material resembles that of classroom lectures in introductory agricultural economics. No unique perceptions nor solutions are presented.

The discussants of chapter 1 focused on regional problems or those in which they had a vested interest. The reaction from the floor was to propose solutions to perceived problems and to solicit reactions from the panel of discussants. The participants in the task force and at the summit seem not to have grappled with fundamental resource allocation and production cost problems.

The task force report on "Farm Commodity Prices and Income" (appearing as chapter 2) generated the most hostility from the farmer segment of the audience. A major reason was that it was less than subtle in indicating that high price supports are not the answer to the price and income situation. This thesis is supported by data that include some fairly complicated derivations. Cash flows are identified as a comparatively new ailment, and heterogeneity of individual farms is stressed. Chapter 2, like the others, is identifiable with its task force chairman, but it also contains a section on task force perceptions allowing the reader to identify the task force members' preferences and responses to issues in farm policy.

The task force report on "International Trade" (chapter 3) also met with reaction from the farmer segment of the audience. They

simply did not agree that the long-run interests of society and agriculture are best served by open trade objectives. Chapter 3 identifies those impediments to open trade that should be addressed by policymakers. The opposing view is that these changes either cannot be made or will take too long so the short-run alternative should be offsetting controls or agreements. The discussants found the paper too academic.

Chapter 4, "Nutrition, Product Quality and Safety," recognizes the broader context of food and agriculture policies. The summit was held at the end of the seventies. At the beginning of that decade, a national farm summit would not have occupied itself with this subject. The inherent dilemma is captured by the following question: "When private choices, even if fully informed, lead to public health problems, who shall decide on the nature and extent of remedies?" Chapter 4 examines the controversy surrounding nutrition, quality, and safety of food. The writers admit that the task force could not recommend a feasible set of goals that would improve the nutritional quality and safety of the American diet. The task force could not achieve consensus except on the point that a way needs to be found to formulate a policy that would satisfy all interested parties. The chapter is a good statement of the controversy and suggests that the task force grappled with the issues.

The fifth chapter, "Agriculture's Role in Government Decisions," is also new to the area of agricultural policy. It should be interesting to those who believe the U.S. Depart-

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ment of Agriculture should be reharnessed as a political power base for production agriculture. The theme of the chapter is that agricultural interests should refrain from ideological demagoguery and concentrate instead on building coalitions with other interest groups. Parts of the chapter read like a sermon directed to those who either believe production agriculture has no political base or to those who believe that those in production agriculture need not be concerned with consumer interests, environmental interests, the regulators, and the Government. The only chinks in what appears to be a consensus are two footnotes by a task force member who takes exception to examples that contrast positions of public benefit with negative individual costs. The discussants agreed with the report in principle. As the task force chairman and discussants all worked in Washington, D.C., it could be expected they would be comfortable with coalition politics.

Chapter 6, "Summit Review," classifies and summarizes the major points and attempts to identify points of consensus. Chapter 7, "Comments of the American Agriculture Movement," presents views that conflict with many of the statements contained in the task force reports. The reader can gain perspective on the consensus and conflict by reading these two chapters first.

In this reviewer's judgment, *agricultural economists* will be most interested in chapter 4 and in the last two chapters. The book will not provide much new knowledge, but is interesting. Students of agricultural policy should add it to their general reading list.

Producers will get an exposure to academic attitudes on production and trade and an economist's explanation of their problems. Producers will recognize several areas of disagreement among farmers, academics, and bureaucrats.

Consumers may be surprised by the pervasiveness of the distrust for their advocates. They will be reminded of their good fortune regarding quantity, quality, and price of food. They may also be surprised by the degree of conflict within the total food-producing system and by the discovery that there are advocates of improved nutrition who believe direct Government action is needed.

Government policymakers familiar with food and agriculture policy will find little that is new. They may gain some appreciation for the heterogeneity of the agricultural sector. The book should allay any fears that there will be no policy issues to address during the eighties.

Political scientists should gain a sense of the task facing the political system. They will be disappointed if they expect to find well-defined alternatives suitable for political debate and decision-making.

THE INNOVATOR'S SITUATION:

UPPER-MIDDLE-CLASS CONSERVATISM IN AGRICULTURAL COMMUNITIES

Frank Cancian,
Stanford University Press, Stanford, Calif., 1979,
159 pp., \$12.50.

*Reviewed by Robert D. Munoz**

Competition among farmers for social and economic rank affects who adopts new technology. Frank Cancian examines this hypothesis by attempting to demonstrate that, in the broad middle range of farmers who are neither rich nor poor by local standards, a large percentage of those who are lower middle class consistently adopt innovations earlier than those who are upper middle class. Only later, when the first returns are in and the innovation is judged successful do farmers of upper-middle rank adopt the technology in comparable proportions.

Cancian's theory tries to explain why both low-middle-rank farmers and high-rank farmers seem to adopt innovations faster than the upper-middle rank group. His theory is stated in a general way, relating economic rank to the risk of various agricultural enterprises used to gain and maintain that rank. Cancian uses two hypotheses to test for the fundamental principles in the inhibiting effect-of-rank explanation of an upper-middle-class conservatism in the adoption process. The first hypothesis tests whether in the early stages of the spread of an innovation, low-middle-rank individuals are more likely to adopt it than are high-middle-rank individuals. The second hypothesis tests whether, in the later stages of the adoption process, the adoption rate of high-middle-

rank individuals will increase relative to the adoption rate of low-middle-rank individuals.

To test these hypotheses, Cancian examines secondary data from eight countries: India, Japan, Kenya, Mexico, Pakistan, the Philippines, Taiwan, and the United States. He analyzes data on more than 6,000 farmers included in 23 studies by rural sociologists, anthropologists, and agricultural economists.

Cancian summarizes his study in three sentences:

- (1) It is useful to distinguish between an early stage in the spread of an innovation when uncertainty is high and a later stage where knowledge about the implications of using the new practice is much more widespread.
- (2) In the first stage of the spread of an innovation, farmers of high-middle position are apt to be conservative compared with those of low-middle position in the community.
- (3) In the second stage of the spread of an innovation, these high-middle-rank farmers catch up so that the overall relation of economic rank and adoption becomes monotonic positive. That is, the relation of rank and innovation varies in a predictable way over time.

The implications of these findings for agricultural development policy are broad. Many programs to help small farmers are usually aimed at upper-middle-class farmers. The reason is that, in many

less developed countries, the upper-middle-class farmers appear to be the only ones except the rich with viable commercial farming operations. If the programs fail to induce adoption among the upper middle class, the conclusion is that a program designed to give lower-middle-class farmers access to new agricultural practices will also fail. According to Cancian, the failure of a program designed for the upper middle class cannot be taken as evidence that poorer local farmers will resist or reject new practices.

This book adds to the body of knowledge on theories of innovation by filling the gap—within the middle class of farmers—on who is most likely to adopt innovations. It goes beyond the assumption that larger, richer farmers are more likely to adopt innovations than smaller farmers.

The book has several shortcomings. The first, most obvious problem is its reliance on secondary data which may have errors that cannot be identified or corrected. A second problem is Cancian's economic rank hierarchy, which is based on the assumptions that economic position is important to people and that most people expend great effort gaining and maintaining their economic rank. These assumptions may not be true of all agricultural societies. There are agricultural communities based on the barter system where economic rank means little and there are others at a subsistence level where survival is the main goal. However, Cancian's book is well written and worth reading by the student of adoption-of-innovation theory.

*The reviewer is a rural sociologist with the Economic Development Division, ESS.

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